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SPACE STATION NEEDS, ATTRIBUTES, AND ARCHITECTURAL OPTIONS

volume II - book 3
cost and programmatics

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ILLUSTRATIONS

ILLUSTRATIONS (contd)

1 - SUMMARY

1.1 INTRODUCTION

This volume describes the cost and programmatic considerations which integrate mission requirements and architectural options into a cohesive system for exploitation of space opportunities within affordable limits. Section 1 provides a summary of mission requirements, baseline architecture, a top level baseline schedule, and summary acquisition costs.

Section 2 describes the Work Breakdown Structure (WBS) used to structure the program, and provides the WBS dictionary.

Section 3 describes the costing approach used in the study, including the operation of the primary costing tool, the "SPACE" cost model. The rationale for the choice of Cost Estimating Relationships (CERs) is given and costs at the module level are shown. Detailed costs at the subsystem level are shown in the "SPACE" output runs included in Appendix A.

Section 4 provides the baseline schedule and annual funding profiles. Alternate schedules are developed to provide different funding profiles. Alternate funding sources are discussed and foreign and contractor participation is outlined.

Section 5 describes the results of the benefit analysis and outlines the accrued benefits deriving from an implemented Space Station program.

1.2 MISSION BENEFITS

1.2.1 Introduction

Analysis of Space Station requirements encompasses the full range of possible space missions covered by U.S. national security plus domestic and foreign missions and include commercial, science and applications, and technology development. In essence, the whole world of space missions was analyzed to identify those missions which need or can gain a significant benefit from the availability of a Space Station.

Major inputs to the study were derived from prior studies on NASA Space Station related mission systems, NASA & DoD Space System Technology Models, related foreign mission studies, plus ideas from the Contractor Orientation Meeting and our Constituency Development Council.

1.2.2 National Security Mission Benefits

Practical uses of a Space Station in support of future military requirements has been investigated for 16 conceptual missions described in the DoD Space System Technology Model. The missions considered include surveillance, weather, navigation, and communications space systems, which have been analyzed with respect to the three Space Station functions related to R&D/proof of concept development, assembly/deployment/servicing space operations, and resident operations. Our analysis shows that significant benefits could be derived from using an orbiting Space Station to support mission development of large space systems and to provide space operations support for assembly/deployment/servicing.

1.2.3 Commercial Mission Benefits

In the commercial area, three types of missions were investigated: commercial communication satellites (conventional and new initiatives); materials processing production (pharmaceuticals and other products); and remote observation services (special order or repetitive). We found some benefit from use of Space Station capabilities; for example, development and deployment of a 100-m dia land mobile communications geosynchronous satellite with a space-based reusable upper stage is shown to be nearly $300M less costly, and probably less complex to develop, than a comparable Shuttle-launched expendable-Centaur. Potential savings are also shown for two material processing missions that are dedicated to the production of medical isoenzymes and mercury-cadmium-telluride crystals.

A low earth orbiting Space Station must operate in a high inclination orbit for cost-effective commercial observations. Other commercial missions are more economically performed in a 28.5° orbit, because that orbit maximizes the Shuttle payload delivered capability from KSC. Upper stage transportation costs for delivering geosynchronous communication satellites will also be minimized from 28.5°.

1.2.4 Science and Applications Mission Benefits

Science and applications missions encompass astrophysics, planetary science, life science, solar and terrestrial observatories, and global environmental measurements. Missions in this category were analyzed for their applicability to a Space Station program. The missions were then grouped according to their preferred mode of operation with respect to the Space Station, (i.e., within an internal laboratory, externally mounted, or as a free flyer). Beneficial use of Space Station capabilities for development, space operations, and resident mission operations were considered on a global basis. Specific incremental benefits of using Space Station capabilities were found for the Bio-lab, imaging radar experiment, and Advanced X-ray Astrophysics Facility (AXAF) satellite.

The Space Station is required to operate in both high inclination and low inclination orbits for science and applications missions. Within these orbits the Space Station can take over and economically extend current sortie missions, provide satellite servicing functions, and provide a platform for future man-tended science missions. The 28.5 deg orbit is the best orbit to accomplish most R&D work. As before, this orbit is also best for low-cost transportation to geosynchronous orbit and beyond. Some special conditions in the polar regions require high inclination orbits.

1.3 BASELINE ARCHITECTURE

Our basic motivation was to optimize mission needs and payoffs with a reasonable funding profile. We have baselined an evolving space station which develops into a large, versatile complex for service to the industrial, military, and scientific communities.

The initial space station has one pressurized module that houses three men and necessary subsystems, a life sciences laboratory, and an EVA control/monitor area. Tunnel extensions provide berthing parts for a visiting orbiter. An external subsystems pallet mounts batteries for darkside power, power conversion, and controlled moment gyros. A mast extends to mount an astrophysics viewing instrument at its tip, and solar arrays are used for the main power supply.

The physical evolution of the space station has been accomplished by addition of pressurized modules, by addition of surrogate structures to increase EVA crew, by addition of more solar array area to meet increased electrical power demands, and by increased observation capability.

These additions include two space manufacturing laboratories (using the identical shell of the initial space station habitat). These are followed by two 3-man capacity habitation/life science laboratory modules, additional subsystems including added power, the three additional surrogates (for EVA capacity) and additional observation capacity.

Besides the initial manned Space Station, a tended polar orbit platform will be launched with its own power supply and a pressurized subsystem module with life support system for temporary manned occupancy.

Several (four in present planning) industrial platforms are required, each with a pressurized subsystems module capable of providing a shirtsleeve environment plus external subsystems capability and power supply.

1.4 SUMMARY SCHEDULES

The baseline schedule (see Fig. 1.4-1) assumes an ATP at the beginning of FY'87 and a four year C/D Phase, with an Initial Operating Capability (IOC) at the end of FY'90 for the Initial Space Station. The Evolved Space Station is complete at the end of FY'92, which also marks the IOC of the first Tended Industrial Platform. All of the foregoing will be in 28.5° orbits. The Initial Tended Polar Platform is shown to be operational at the end of FY'95, with the Evolved Configuration following in one year.

A reusable space based Orbital Transfer Vehicle (OTV) is assumed to be operational at the end of FY'92.

1.5 ACQUISITION COST SUMMARY

Figure 1.5-1 shows Station/Platform-level acquisition cost estimates for the evolving space station and its associated platforms. Acquisition costs shown include contractor costs without fee. They also include (as part of production cost) the

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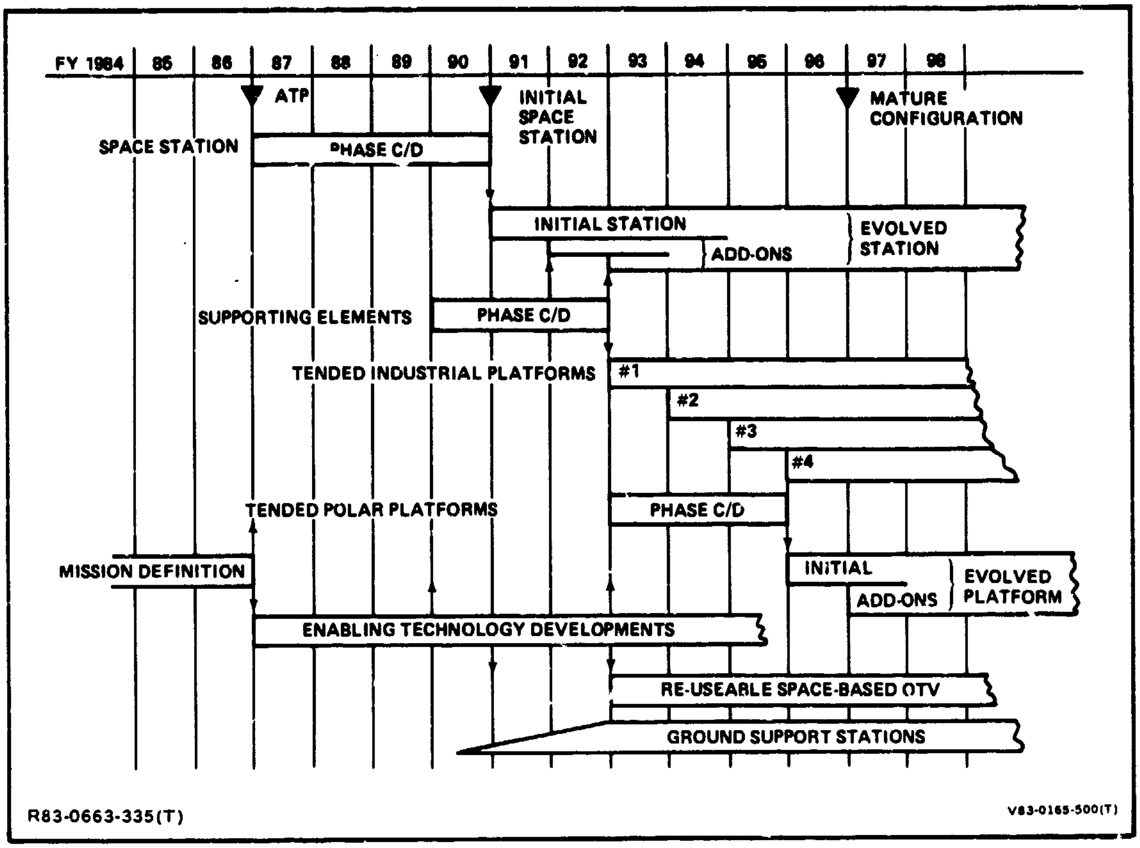

Fig. 1.4-1 Space Station Development Baseline Schedule

	PHASE	DDT&E	PRODUCTION*	TOTAL
28 1/2	INITIAL SPACE STATION	3165	1114	4278
	SPACE STATION ADD ON **	376	1312	1688
	INDUSTRIAL PLATFORM (4)	404	1546	1950
	TOTAL	3945	3972	7916
POLAR	INITIAL TENDED POLAR PLATFORM	57	702	759
	POLAR PLATFORM ADD ON	57	382	439
	TOTAL	114	1084	1 98
	TOTAL	4059	5056	9114

*INCLUDES TRANSPORTATION TO LEO

**DOES NOT INCLUDE OTV ACQUISITION

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Fig. 1.5-1 Space Station Summary, Acquisition Costs
(1984$ Millions)

transportation cost to LEO. NASA wraparounds are shown on the detailed cost runs but not in the totals. Detailed descriptions of the methodology used, with module level summaries, are provided in Section 3. Appendix A contains the detailed cost runs, technical details and modifying factors used.

2 - PROGRAM STRUCTURE

2.1 WORK BREAKDOWN STRUCTURE (WBS) DESCRIPTION

The Space Station WBS closely follows the standardized WBS developed by the Standardization Subcommittee of the Joint Government/Industry Space Systems Cost Analysis Group, SSCAG.

Three variations from the SSCAG WBS were made as follows:

- **Modules** - Spacecraft, Transportation, Ground Segments, and Integration and Test at System Level are iterated for each module, effectively inserting another level between Space Station and Segments in order to account for total costs for each module.
- **GSE** - In the SSCAG WBS GSE sums into hardware costs, but in the Space Station WBS GSE was moved up one level to add into the Spacecraft Segment, because the GSE CER used is a function of hardware plus integration and test at system level.
- **NASA Wraparound Costs** - Program Support, Management and Integration, and Launch and Landing cost categories were added to the WBS. These categories catch the NASA costs to combine the various modules and are costs listed for information, but are not included in the Space Station costs.

Figure 2.1-1 is a block diagram of the WBS structure used.

2.2 SPACE STATION PROGRAM WBS DICTIONARY

The Space Station Program (from a summary cost viewpoint) contains all labor and material required for the DDT&E, Production and Operation phases for all program elements. These phases are defined as follows:

DDT&E - Includes all labor, materials, tooling, facilities, studies, analyses, etc, which are required to determine specification requirements and the subsequent analysis, design, development, evaluation and redesign for the subsystems. Specifically included are the preparation of specifications, drawings, parts lists, wiring

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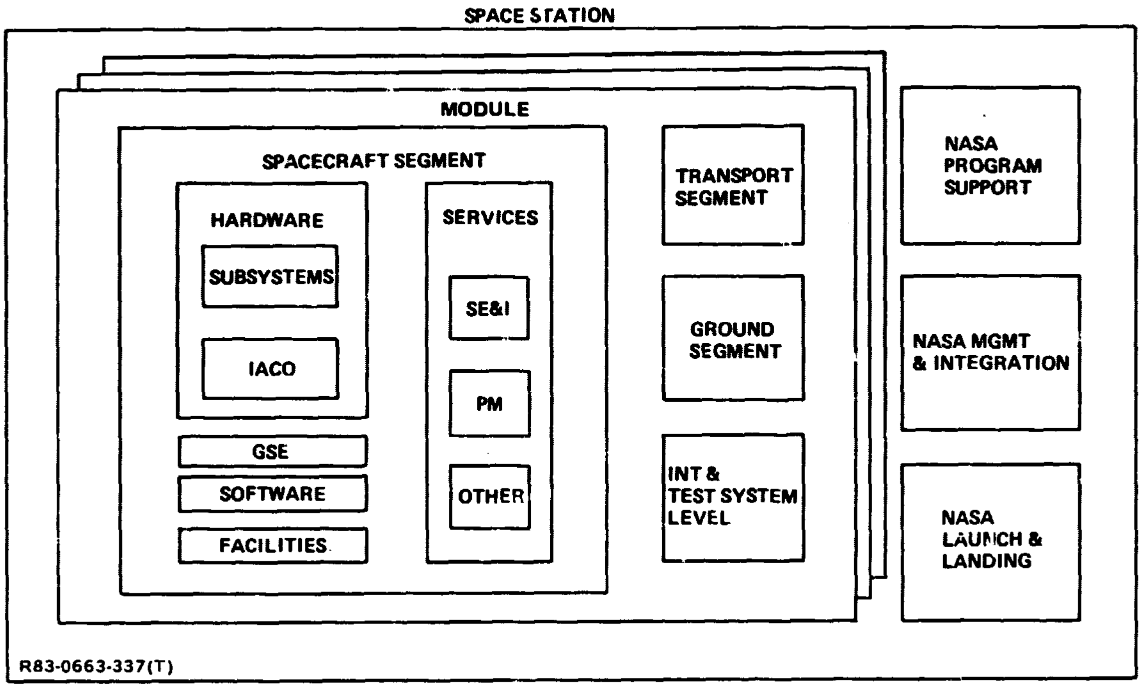

Fig. 2.1-1 Space Station WBS Organization

diagrams, technical coordination between engineering and manufacturing, vendor coordination, component and subsystem hardware development and testing, data reduction, report preparation, determination and specification of requirements for reliability, maintainability, and quality assurance. In addition, costs are included for efforts to complete the planning, design, fabrication, assembly, inspection, installation, and modification of initial tooling, jigs, fixtures, and special test equipment/GSE. Also included in this item is the effort expended in conducting system design reviews, evaluating the results of those reviews, and performing engineering cost analysis and materials analysis. This includes subsystem management and engineering which is directly charged to a particular subsystem or component. DDT&E also includes costs associated with developmental test articles including major ground test articles and developmental testing costs. It includes such hardware as engineering models, breadboards, engineering mockups and such other hardware as required in the development of individual subsystems and components.

Production - This item includes all labor and materials required for the production of Space Station hardware, through the acceptance of this hardware by the Government. Space Station hardware includes all hardware produced for deployment in space, as well as all hardware fabricated, assembled and checked out in space. Specifically included in this item are all costs associated with the following:

- Procurement, fabrication, assembly and checkout of Space Station hardware
- Ground test and factory checkout of Space Station hardware
- Initial spares
- Maintenance of tooling and factory test equipment/GSE
- Sustaining engineering for liaison support of Space Station hardware production.

Operations and Support (O&S) - This item includes all costs associated with ground and flight operations and the support of these operations. Specifically included in this item are all costs associated with the following:

- **Ground Operations** - Receipt, assembly, checkout, servicing, launching, post-launch support, and maintenance/refurbishment of the reusable Space Station hardware as required at the launch site

- **Flight Operations** - Mission planning, in-orbit mission execution and ground mission control support
- **Support Operations** - Transportation and handling of Space Station System hardware requiring special consideration, training equipment, training programs and space hardware/GSE operational spares.

The WBS definition detailed below is intended to apply, as appropriate, to the DDT&E, Production, and Operation phases of the program. The summation of costs for these phases comprises the total program costs.

2.3 WBS DEFINITION

2.3.1 Space Station

This is the summing element for a total space system. It collects and summarizes the resources required to acquire and operate the space station, space-transportation, and ground segments over their total life cycle. It also includes the effort to integrate these segments into a complete space system, and transportation to orbit.

2.3.2 Modules

This element sums the spacecraft segment, ground segment, and integration and test at system costs for each of the modules listed as separate units.

2.3.3 Spacecraft Segment

This is a summing WBS entry for the resources needed to acquire and operate a module. It includes hardware, software, services, facilities, and GSE.

2.3.3.1 Hardware - This element collects the costs and resources directly associated with the module hardware. It includes costs for analysis, design, tooling, test, fabrication and checkout, but excludes software and services not associated with specific end-items, facilities and GSE.

Integration, Assembly & Checkout (IACO)

This element covers hardware-related costs and resources needed to develop and produce an integrated module. It includes analysis and design at the module

level, testing at the same level, and final assembly/checkout. This WBS entry covers acquisition phases only.

Subsystems

This element sums the development and production costs for all subsystems in a module.

For each subsystem (structure, EPS, communications, etc) a development and production cost is generated which includes design, test, subsystem test hardware, production, qualification and acceptance testing, and subsystem assembly.

2.3.3.2 **Software** - This WBS element collects all software costs associated with the development and implementation of computer programs for the module. It includes both spacecraft and ground-based computer programs.

2.3.3.3 **Services** - This is a summing element for all module costs that are not end-item oriented; it covers both the acquisition phases, and also the O&S phases. Included in this WBS entry are engineering, management and support services. It also includes data administration, control, and reproduction.

System Evaluation & Integration (SE&I)

This element includes the following activities on the module level:

Requirements Analysis
Interface Definition
Design-to-Cost/Life Cycle Cost Analysis
Technical Performance Management

Program Management

This element includes the management activities of planning, organizing, directing, coordinating, controlling and approving actions to ensure program success. Includes configuration management, documentation, management reviews, change boards, budgeting, schedule planning, contract administration and management of test programs, GFE, information systems, subcontractors, and procurement functions.

Other

This element includes deliverable data publications, training, product effectiveness, liaison engineering and manufacturing services.

2.3.3.4 Facilities - This entry collects costs for new construction or for the modification of existing production facilities, provided that these costs are reportable expenditures rather than the contractor's own capital outlay. Production facilities comprise plant, office space, specialty areas (e.g., clean rooms), and their associated utilities.

It includes costs for new construction or the modification of existing test facilities, provided that such expenditures are reportable costs rather than the contractor's own. Test facilities include buildings, test stands, chambers, fluid supplies, environment simulators, and supporting office areas.

2.3.3.5 Ground Support Equipment (GSE) - This WBS item collects costs for the design and production of ground support equipment (GSE) for the module. It includes costs for module check-out, handling, transport, and servicing equipment. However, costs for component-level manufacturing test equipment (bench test equipment) are excluded because these are included under the individual subsystems WBS elements.

2.3.4 Ground Support

This item collects all resources needed to acquire and operate the ground segment. It covers all ground based facilities, equipment and software needed to support the module in space. It excludes launch facilities and all ground support equipment used in support of flight hardware. It includes hardware and software directly associated with the ground equipment to control and maintain communication with the module as well as mission data processing.

2.3.5 System Level Integration and Test

Resources needed to integrate and test modules at space station level. It includes performance integration and ground tests to verify vehicle hardware integrity and performance. It includes major test articles, instrumentation, prototype, qualification units, and test program costs.

2.3.6 Program Support (NASA)

In-house and contract efforts chargeable to program, but not falling under prime contractor's responsibility. Includes: trainers and simulators, government furnished equipment, crew procedures development, mission control center and data reduction center modification, and flight planning and analysis. Also, test, evaluation and analysis efforts for labs, test chambers, and other test facilities.

2.3.7 Management and Integration (NASA)

Efforts such as performed for space shuttle by Rockwell under the title Program Integration, and by Boeing when they integrated the Saturn V stack.

2.3.8 Launch and Landing (NASA)

Includes the second line of ground support equipment, modification to the launch processing system, special handling equipment installation and integration at KSC, and logistics and ground support.

3 - COST STRUCTURE AND METHODOLOGY

3.1 APPROACH

Since detailed engineering designs were not required or desired for this study, virtually the only feasible costing approach was by parametrics.

Parametric estimates are derived by statistically correlating historical cost of several systems to physical or performance characteristics of those same systems, and then using the identified characteristics, or cost drivers, of the system being estimated to calculate the cost of the subject program. The observed mathematical relationship between cost and technical variables (called Cost Estimating Relationships (CERs)) are treated as time-constant expressions of reality, subject to revisions only as additional and more current data can be observed and reflected in the mathematical expressions. The inherent assumption of this approach is that the same forces that affected costs in the past will effect them in the future as well.

The cost driving parameter used in most of the subsystem CERs is weight. To input the CERs, an experienced weights engineer reviewed each of the architectural configurations; then by analogy or direct calculations, he estimated the most likely weight. Other cost driving parameters, such as power for solar arrays, were estimated from requirements or analogy.

3.2 "SPACE" COST MODEL

The Grumman in-house cost model called Systems Parametric Algorithm for Cost Estimating (SPACE) was used to facilitate the cost calculations and graphics for this study. This computer program provides rapid and accurate cost computations, repeatability, and consistency of results. Due to the program's modularity and generalized structure, the costing for any WBS can be easily programmed. This model was utilized throughout the study and it was effective for costing the many options and configurations considered during this period.

The SPACE cost model computes DDT&E, Production and Operations cost phases of the system life cycle using either the deterministic or probabilistic methods. In

the current study, Operations and Support costs were calculated off-line. Due to the many options and configurations developed during this study, the deterministic routine was used for all program option costing. Annual funding tables with corresponding graphics (Gould plots) were generated. SPACE was used for cost tradeoffs, costing by plateaus and sensitivity analyses in this study.

In developing SPACE, an effort was made to eliminate several shortcomings of other cost models and to provide as much versatility as possible. This was achieved by developing a set of core programs which remain the same for all jobs. A user, however, must write a few additional subroutines peculiar to his particular WBS which specify the particular costing methodology for each item of the WBS. This is facilitated by the incorporation of a sizeable computerized data bank of CERs which was compiled over the years. These CERs are readily accessed by simple call statements as required. The model's capabilities are as follows: parametric cost estimating (both deterministic and probabilistic) to any given WBS, cost risk analysis, annual funding distribution and output format flexibility. SPACE has been used in 15 space system studies since its conception.

Typical space model inputs are: (1) learning curve factors; (2) parameters for the CERs; (3) parameters for the risk analysis option (low and high values); (4) commonality, complexity and state of development factors; (5) number of units, both end item and shipset quantities; (6) ground test hardware factors; (7) cost throughputs (cost estimates prepared off line; (8) year of economics, and, (9) annual funding schedules and beta distributions for cost data.

The flexibility of the SPACE computer program allows for both total cost and annual funding tables to be printed at any desired WBS level and also for the quick rearrangement of individual WBS items.

A simplified block diagram of the SPACE computer program is presented in Fig. 3.2-1.

3.3 PARAMETRICS USED

Figure 3.3-1 presents the SSCAG-inspired WBS in block form. Only one Space Station module is shown for clarity. The cost of all hardware items in the WBS were generally estimated at subsystem level by parametric methods. The CERs

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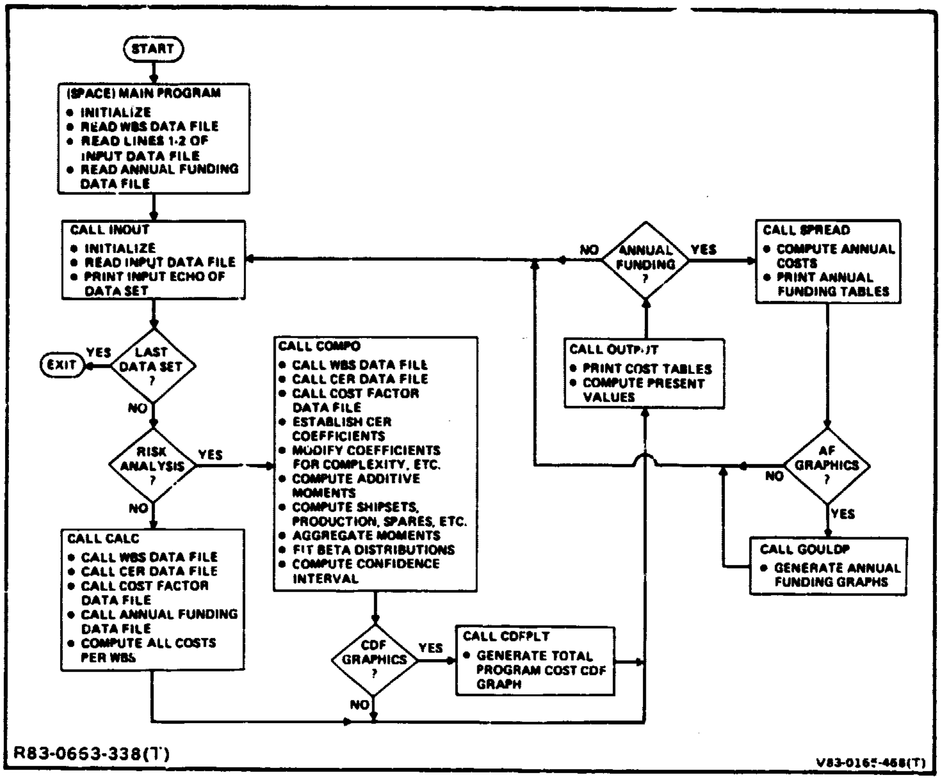

Fig. 3.2-1 Space Cost Model Version 2 Block Diagram

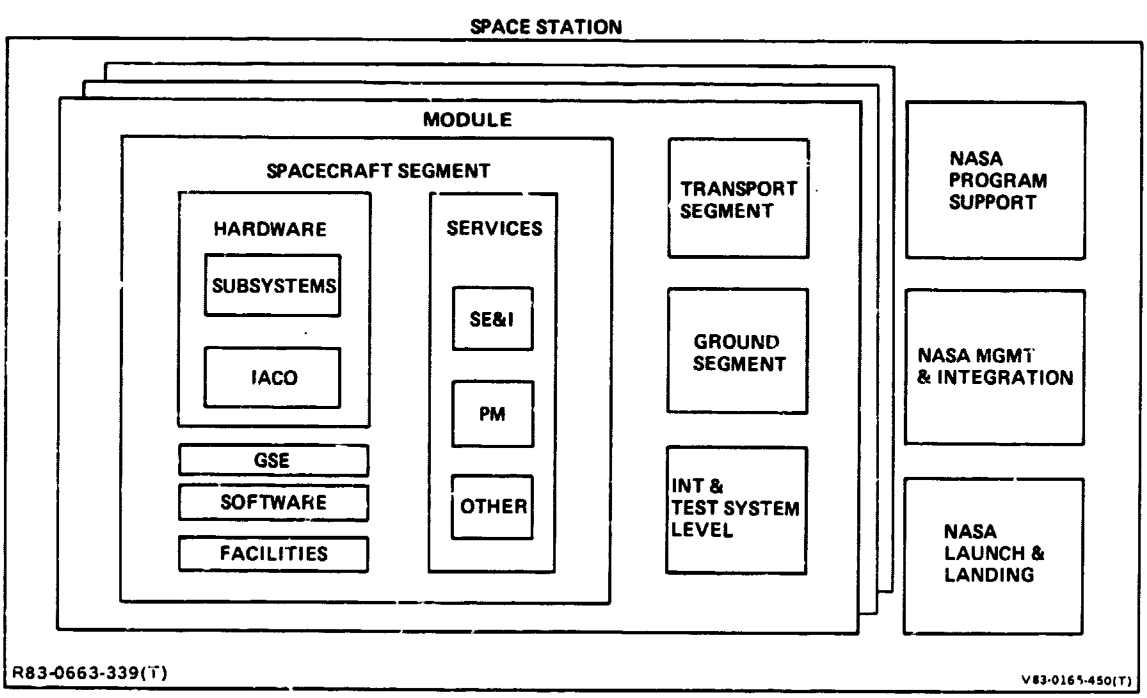

Fig. 3.3-1 Space Station WBS Organization

selected from the data bank were developed by the PRC Corporation or the Air Force Space Division. It was felt that these CERs, based on the broadest available manned space systems cost data base, are most representative of the types of hardware projected for the Space Station modules. Air Force Space Division CERs were used for our unmanned structures. All other CERs were from the NASA/PRC model.

Cost output from these CERs was tempered by appropriate factors to account for:

- Inherited hardware
- Equipment commonality
- Equipment complexity.

In those cases where the utilization of previously developed hardware was identified in a given subsystem, development cost reductions were computed by means of a function presented in Fig. 3.3-2. This was based on the premise that the development cost of 100% off-the-shelf equipment never decreases below 20% of newly designed hardware cost because of documentation and retest requirements.

Commonality of subsystems between various space station modules was reflected in the costing by means of appropriate commonality factors. It was assumed that if a subsystem in a space station module is 100% common to that in another space station module, then its development cost is zero as reflected by the commonality factor of zero. Conversely, a commonality factor of 1 indicates no commonality.

Equipment complexity can be expressed as dollars per kilogram ($/kg) when compared against "baseline" equipment of equal weight and when normalized for a given dollar year. It is generally very difficult to make complexity adjustments to parametrically derived costs because of the lack of design data at this stage of the program and insufficient knowledge about the data bank complexity used in deriving the CER. Technological advancement further complicates this assessment. Quantitative complexity adjustments were, nevertheless, made on selected subsystems based on engineering judgment. A complexity factor of one, therefore, indicates that the hardware to be costed has an intrinsic complexity equal to that implied in the CER, and a greater or lesser complexity is indicated by factors greater or less than one.

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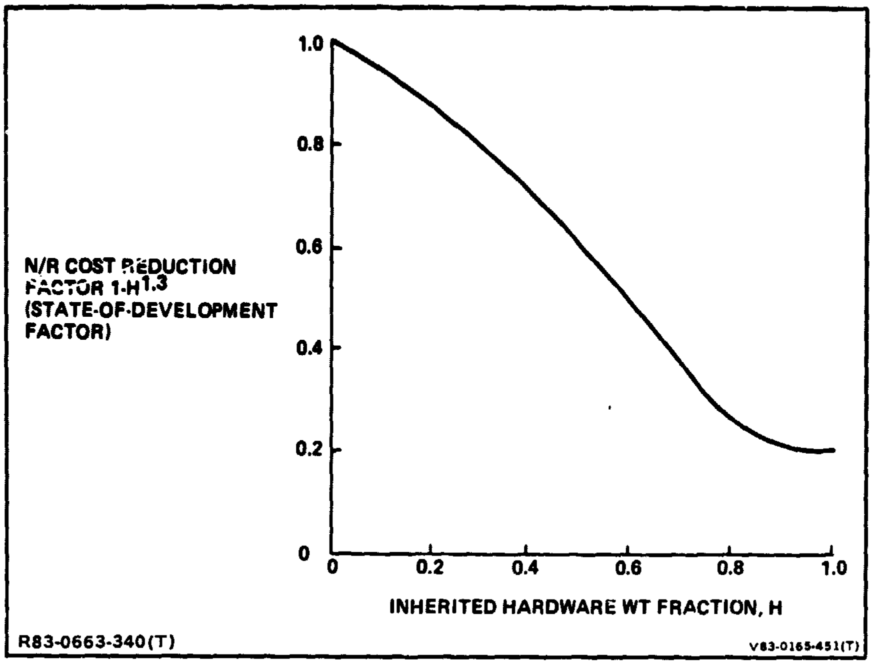

Fig. 3.3-2 N/R Cost Reduction Factor vs Inherited Hardware Weight Fraction

Hardware replication impact on the development cost of subsytems was considered only when sufficient design definition was available. This was accomplished by inputting non-replicated subsystems weights to compute development costs. Replication in the first flight unit cost was accounted for by using the shipset quantity concept and applying appropriate learning factors.

The general form of the DDT&E (Fig. 3.3-3) and production (Fig. 3.3-4) wraparounds is

$$y = a\ (\Sigma\ \text{COSTS}\ /b)^{c}$$

where a, b, and c are constants, and costs are associated with subsystems or other wraparounds.

For DDT&E integration and tests, the total costs are summed as subsystem TFUs; for IACO, the cost is a function of integration and test cost. For GSE, the cost is a function of summed DDT&E subsystem costs plus DDT&E, IACO and integration and test costs.

For DDT&E, SE&I, PM and OTHER costs are a function of summed DDT&E subsystem costs plus DDT&E IACO, plus integration and test, plus GSE.

Production IACO cost is the sum of the Theoretical First Unit (TFU) subsystem costs transformed through the general equation.

Production SE&I, PM and OTHER costs are the sum of the TFU subsystem costs plus IACO, each transformed through their appropriate equation.

NASA wraparounds (Fig. 3.3-5) act only at the module level and are of the general form of

$$y = a\ \Sigma\ \text{MODULE COST}$$

where a is a constant, and the module costs are either production or DDT&E, as appropriate.

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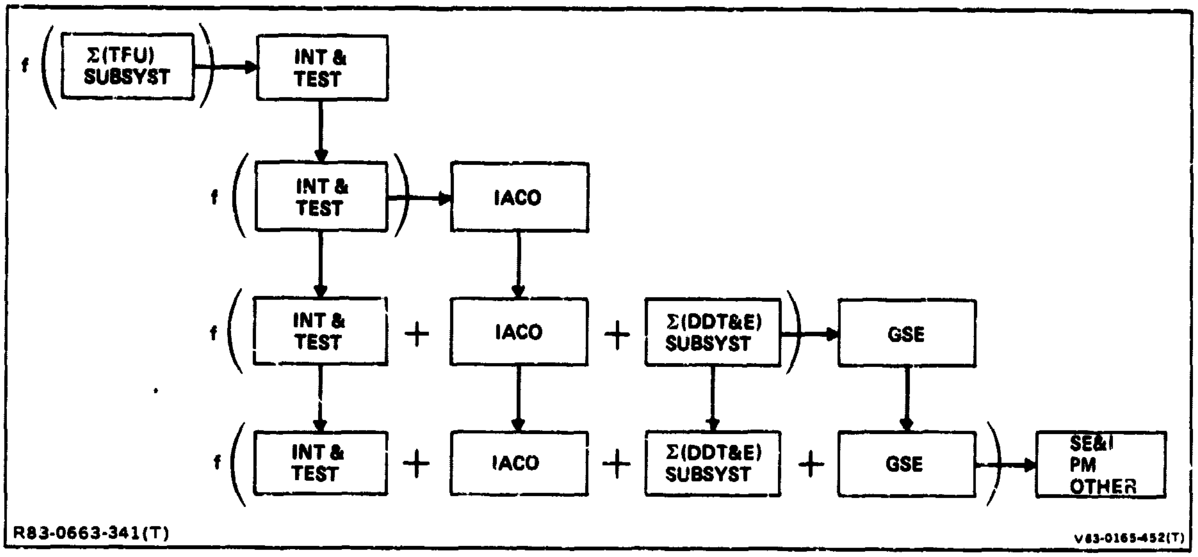

Fig. 3.3-3 Cost Factor Wraparounds – DDT&E

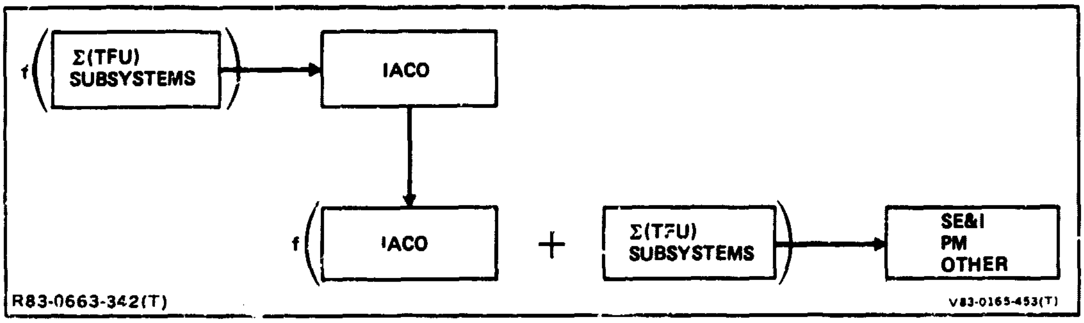

Fig. 3.3-4 Cost Factor Wraparounds – Production

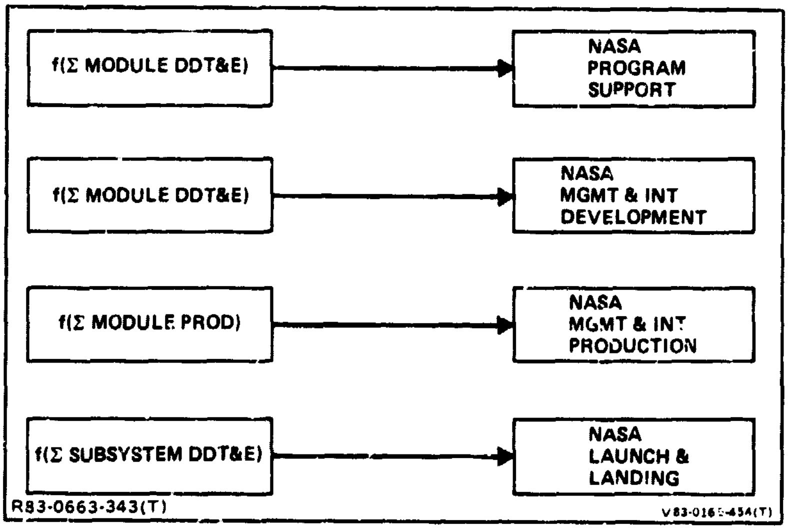

Fig. 3.3-5 Cost Factor Wraparounds – NASA

FORWARD PRICING INDICES

FISCAL YEAR	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92
ESCALATION RATE %	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.6
ESCALATION FROM FY 1982	1.000	1.09	1.188	1.289	1.399	1.517	1.646	1.786	1.938	2.102	2.281
ESCALATION FROM FY 1983		1.000	1.090	1.183	1.283	1.392	1.510	1.639	1.778	1.929	2.093
ESCALATION FROM FY 1984			1.000	1.086	1.177	1.277	1.386	1.503	1.631	1.770	1.920

PAST YEARS TO CURRENT YEAR

FISCAL YEAR	'70	'71	'72	'73	'74	'75	'76	'76	'77	'78	'79	'80	'81	'82	'83	'84
ESCALATION RATE %	6.9	6.3	5.7	5.7	7.2	10.8	9.0	2.1	8.5	7.8	9.5	10.7	10.9	9.0	9.0	9.0
ESCALATION TO FY 1982	2.690	2.530	2.394	2.265	2.113	1.907	1.749	1.713	1.579	1.465	1.338	1.208	1.090	1.000		
ESCALATION TO FY 1983	2.392	2.758	2.609	2.469	2.303	2.078	1.907	1.868	1.721	1.597	1.458	1.317	1.188	1.090	1.000	
ESCALATION TO FY 1984	3.195	3.006	2.844	2.691	2.510	2.265	2.078	2.036	1.876	1.741	1.589	1.436	1.295	1.188	1.090	1.000

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Fig. 3.4-1 NASA R&D Escalation Index

The cost of ground test hardware (GTH) representing major ground test articles, are estimated as percent of an equivalent first flight unit cost. Thus, a GTH factor of 0.5, for example, represents a ground test vehicle costing one-half of an equivalent full-up flight vehicle first unit cost. No learning was applied to ground test hardware because they were considered as pre-production, development vehicles only.

3.4 GROUNDRULES

3.4.1 General Cost Groundrules

- All costs are in 1984 $M. NASA R&D escalation factors as shown in Fig. 3.4-1 were used when required
- Costs are submitted at the subsystem level if estimated at that level; otherwise costs are submitted at level estimated
- Costs are for one space station in LEO, one 97° tended scientific platform, and four tended industrial platforms
- No weight contingencies were added because the estimated weights reflect the most likely configurations
- Facility costs are omitted on the assumption that existing facilities can be used
- All costs are inclusive of prime contractor G&A; fees are not included.

3.4.2 Acquisition Cost Groundrules

- DDT&E costs include conversion of a ground test article into a flight-worthy ground spare
- All shuttle launch costs to insert modules in orbit are included in production costs as a "Transportation Module." Shuttle flights for resupply and crew rotation are considered O&S costs
- Production of second and subsequent flight articles will not require a stoppage of the production line
- All ground assembly and installation costs are included in installation, assembly, and checkout. Space assembly is considered to be accomplished by the shuttle crew and hence not separately costed
- Initial spares are included in production cost

- Due to the assumption of prior development DDT&E costs for satellite servicing equipment, berthing mechanisms, airlocks, pallets, and IPS are omitted.

3.4.3 Operation and Support (O&S) Cost Groundrules

- O&S Phase starts at the establishment of the initial facility at LEO (IOC)
- O&S costs include only Space Station "housekeeping" Operations but not mission related operations
- Space station operation is assumed to last 10 years
- Ground crew labor rate is $30/hour
- For on-orbit IVA operations labor rate is $900/hour
- For routine EVA operations labor rate is $2400/hour
- For non-routine EVA operations labor rate is $16,000/hour plus a fixed cost of $96,000
- Ground crew works 8 hours/day, 250 days/year
- Space crew works 8 hours/day, 180 days/year 60% IVA, 35% EVA, and 5% non-routine EVA
- Space crew has a 10 year tour of duty
- Space crew consists of
  - 3 men (1990-1993)
  - 6 men (1993-1996)
  - 9 men (1996-2000).

3.5 SPACE STATION COSTS

3.5.1 Initial Space Station

The initial 3-man habitat Space Station has a DDT&E cost of $3165M, a production cost of $1114 M (including transportation) for a total cost of $4278M. Most of these costs were generated by the subsystem CERs discussed in the previous sections. The remainder were estimated offline either because they were considered off-the-shelf buys or because they were unique and not amenable to treatment in our existing CERs. All off-line costs were included in the model as throughputs and summed with the model generated costs and wraparounds to the module, and finally the s stem level. They are tabulated by major module in Fig. 3.5-1; the configuration is shown in Fig. 3.5-2. The subsystem level costs are shown in Appendix A.

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MODULE	DDT&E	NO. OF UNITS	PRODUCTION	TOTALS
HABITAT	1702	1	386	2088
LOGISTICS	260	3	68	328
SURROGATE	400	1	90	489
OBSERVATORY	179	1	30	208
EXT SUBSYSTEMS	624	1	351	974
AIRLOCK		1	22	22
TRANSPORTATION			168	168
TOTALS	3165		1114	4278

REFERENCE RUN 37-1

R83-0663-345(T) V83-0165-456(T)

Fig. 3.5-1 Data Form A – Initial Space Station (FY '84$ Millions)

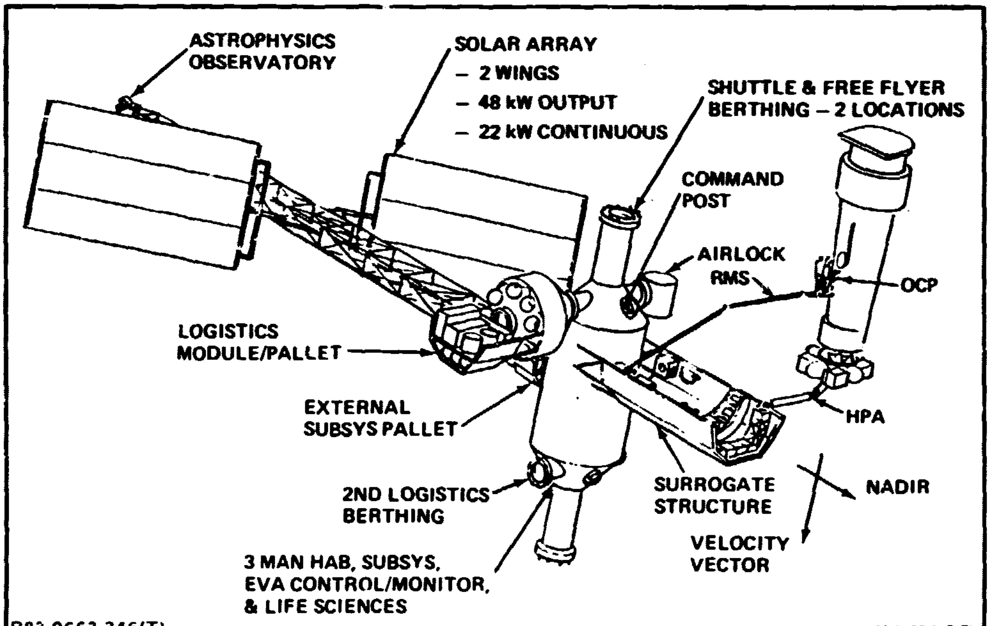

Fig. 3.5-2 Initial Configuration

The PRC CERs are used for structural cost estimates for all man-rated structures. For non man-rated structures, AF Space Division's CERs are used resulting in a lower estimate.

A conservative approach was taken to estimate the quantity for each module. When a module was designed, it was assumed that both a test and a flight article would be built. After testing the test module would be refurbished for use as a ground duplicate or a flight spare if necessary. This refurbishment was judged to cost 0.6 of the Theoretical First Unit (TFU) cost.

All satellite servicing equipment costs were escalated from costs developed for Grumman's Satellite Servicing Systems Analysis Study of 1981. It was assumed that the equipment will have been developed by 1984 and hence no DDT&E costs are designed to the Space Station. Costs for the Airlocks, Berthing, and IPS were estimated by PRC CERs offline and then inserted into the cost program as throughputs, again assuming full prior development.

Transportation costs were based on the published $70.8M cost per shuttle flight in 1982 dollars. Escalation to 1984 resulted in a cost of $84.1M. The total transportation cost was derived by adding all shuttle flights needed for each Space Station configuration, multiplying by $84.1M, and showing the resulting cost in the production column. Only those flights to initially establish the Space Station are shown. Transportation costs for resupply and crew rotation were considered O&S costs. Two flights were required to carry the initial station as described in detail in Volume 2 - Book 2.

General Electric prepared estimates for the onboard data system, hardware and software. Specific cost values were obtained by utilization of appropriate RCA "PRICE" cost models for both hardware and software. Input data was synthesized based upon assumptions of appropriate parameters. These assumptions reflect General Electric's experience with generic designs on other programs. Preliminary runs were made, the data reviewed, and input factors iterated, where appropriate.

The detailed analysis, price inputs, and results are provided in Appendix B.

3.5.2 Space Station Add-On

The evolved Space Station's additional RDT&E cost over the initial configuration is \$376M and the additional production cost is \$1312M as shown in Fig. 3.5-3. The evolved configuration is shown in Fig. 3.5-4. The total cost of the evolved space station is \$5966M.

3.5.3 Tended Polar Platform

The costs associated with the initial tended Polar Platform (Fig. 3.5-6) are tabulated at the module level in Fig. 3.5-5. 3.5-7 lists the additional cost of the evolved Polar Platform over the initial configuration. The total costs of the evolved platform (Figure 3.5-8) in polar orbit is \$3160M.

A detailed breakdown of these costs at the subsystem level is provided in Appendix A.

3.5.4 Tended Industrial Platform

The final evolutionary step in the complete Space Station complex is the tended Industrial Platform, illustrated in Fig. 3.5-10. The costs associated with its DDT&E and production of one flight unit are \$404M and \$387M, respectively. Module level cost breakdowns are shown in Fig. 3.5-9. Subsystem details are given in Fig. 3.5-10.

A summary of the acquisition costs for the complete complex, including four Industrial Platforms is provided in Fig. 3.5-11.

3.5.5 Annual Operations & Support Costs

Annual Operations and Support (O&S) costs were synthesized from the following components:

- Space crew manpower pool
- Real-time ground support staff (including management)
- Training & simulation staff
- Resupply shuttle transportation of logistics module
- Consumables.

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MODULE	DDT&E	NO. OF UNITS	PRODUCTION	TOTALS
HABITAT		2	523	523
LABORATORY	269	2	216	485
SURROGATE		3	91	91
EXTERNAL SUBSYSTEMS	107	1	314	421
TRANSPORTATION			168	168
TOTALS	376		1312	1688

REFERENCE RUN 310-1

R83-0663-347(T) V83-0165-457(T)

Fig. 3.5-3 Data Form A – Space Station Add-On (FY '84$ Millions)

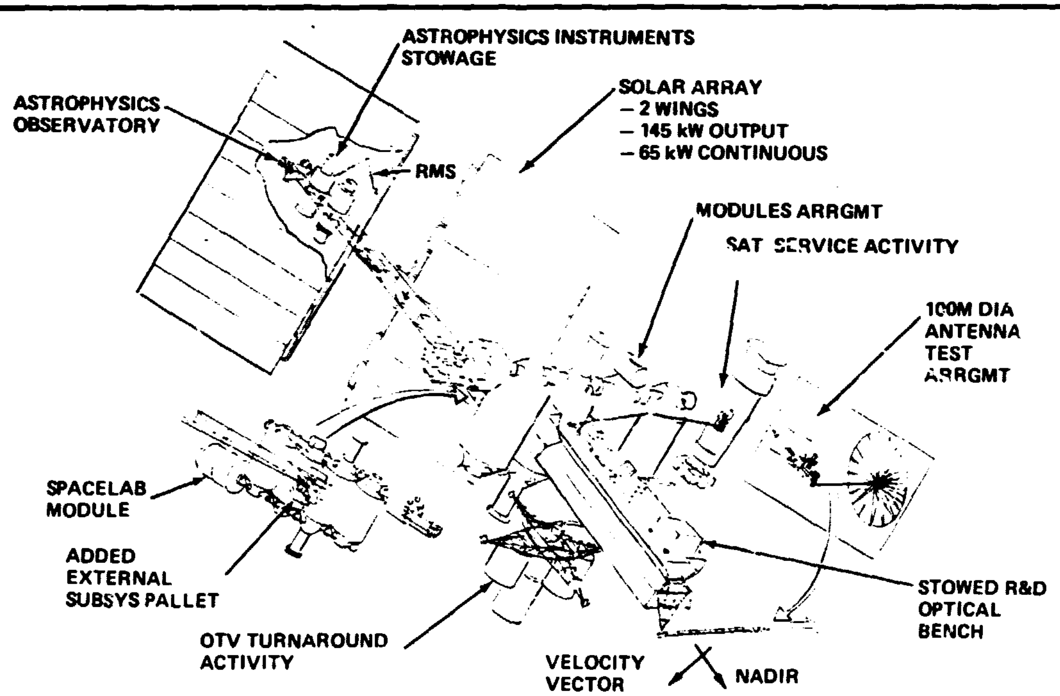

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Fig. 3.5-4 Evolved Configuration

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MODULE	DDT&E	NO. OF UNITS	PRODUCTION	TOTALS
PRESSURIZED MOD	–	1	261	261
SURROGATE	–	4	38	38
OBSERVATION	57	4	91	148
EXTERNAL SUBSYSTEMS	–	1	186	186
TRANSPORTATION	–	–	126	126
TOTALS	57		702	759

REFERENCE RUN 314-1

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Fig. 3.5-5 Data Form A – Initial Tended Polar Platform (FY '84$ Millions)

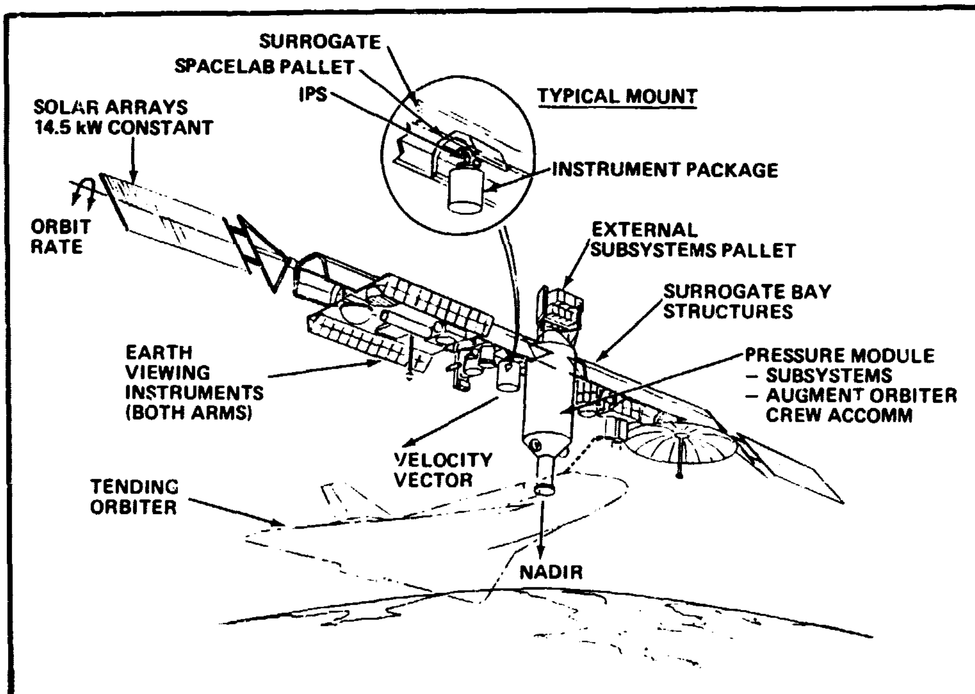

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Fig. 3.5-6 Tended Polar Platform – Initial Configuration

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MODULE	DDT&E	NO. OF UNITS	PRODUCTION	TOTALS
SURROGATE	–	2	22	22
OBSERVATION	57	8	139	[illegible]
EXT SUBSYSTEMS	–	1	136	136
TRANSPORTATION	–	–	84	84
TOTALS	57		381	439

REFERENCE RUN 314-2

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Fig. 3.5-7 Data Form A – Polar Platform Add-On, (FY '84$ Millions)

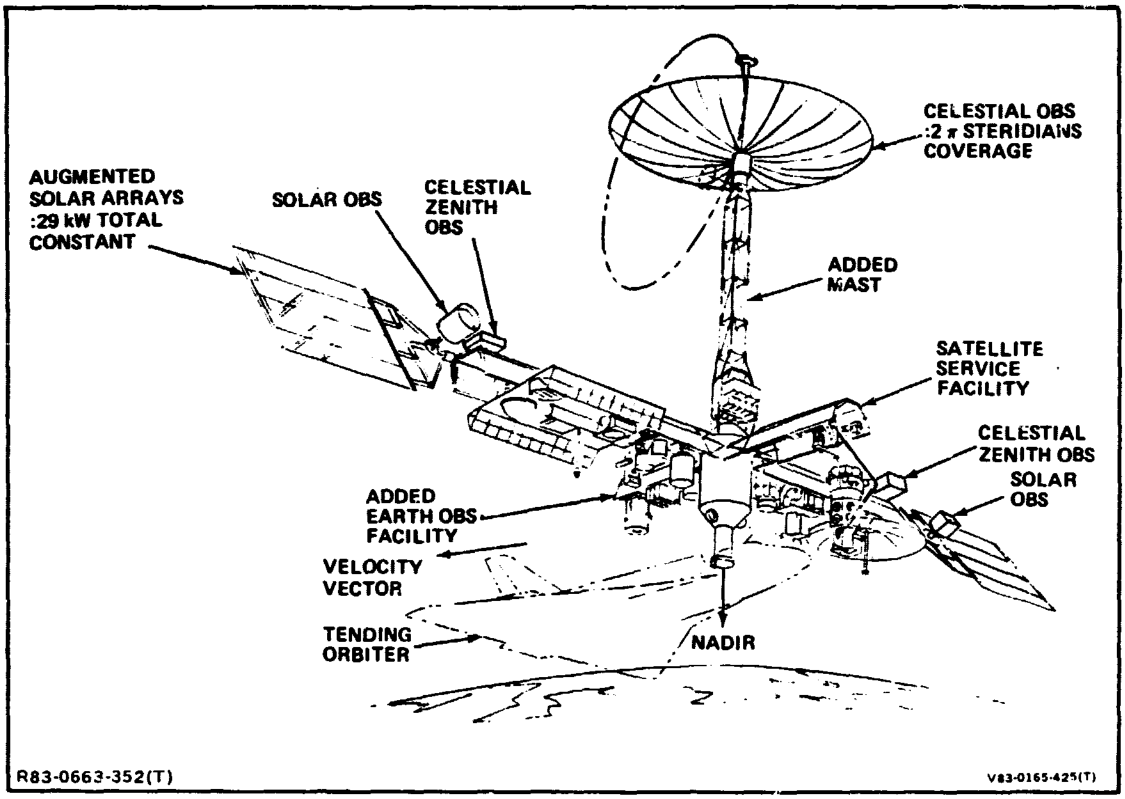

Fig. 3.5-8 Tended Polar Platform – Evolved Configuration

MODULE	DDT&E	NO. OF UNITS	PRODUCTION	TOTALS
TENDED HAB/LAB	404	1	123	527
EXTERNAL SUBSYSTEMS	–	1	200	200
TRANSPORTATION	–	–	64	64
TOTALS	404		387	791

REFERENCE RUN 310-3

R83-0663-353(T) V83-0165-461(T)

Fig. 3.5-9 Data Form A – Tended Industrial Platform (FY '84$ Millions)

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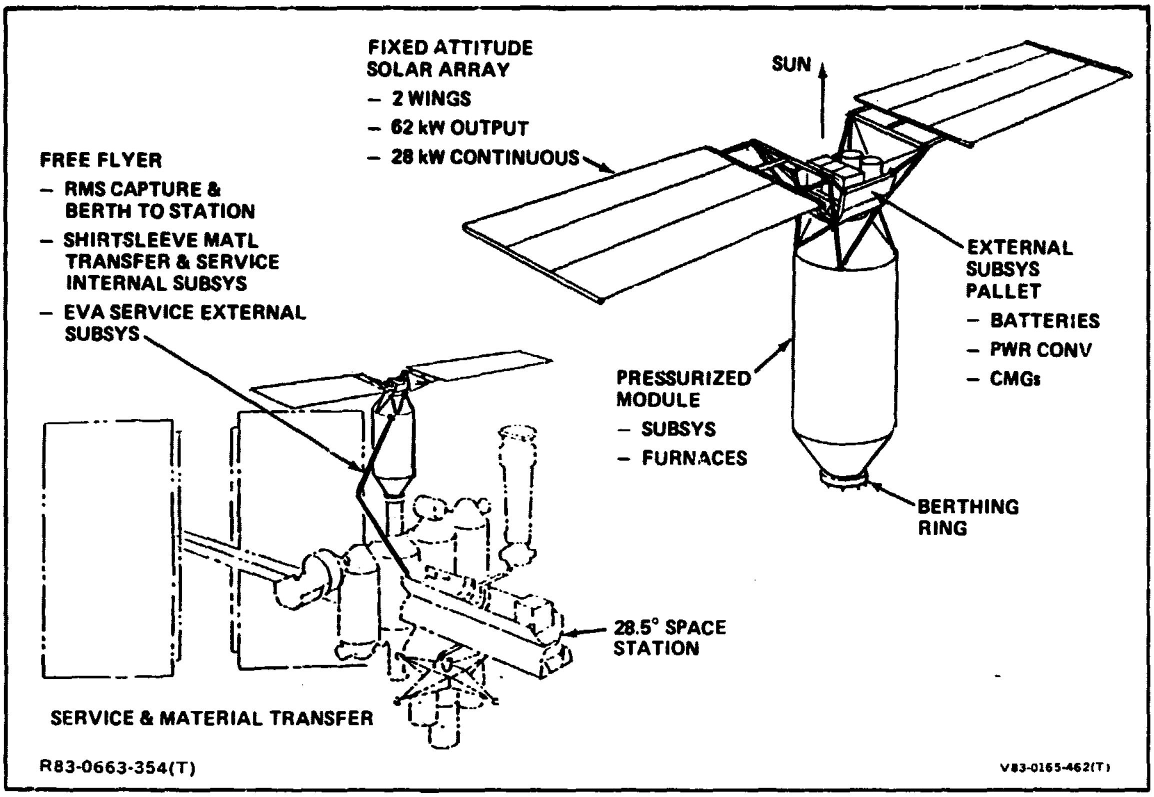

Fig. 3.5-10 Tended Industrial Platform

	PHASE	DDT&E	PRODUCTION*	TOTAL
28 1/2	INITIAL SPACE STATION	3165	1114	4278
	SPACE STATION ADD ON **	376	1312	1688
	INDUSTRIAL PLATFORM (4)	404	1546	1950
	TOTAL	3945	3972	7916
POLAR	INITIAL TENDED POLAR PLATFORM	57	702	759
	POLAR PLATFORM ADD ON	57	382	439
	TOTAL	114	1084	1198
	TOTAL	4059	5056	9114

*INCLUDES TRANSPORTATION TO LEO

** DOES NOT INCLUDE OTV ACQUISITION

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Fig. 3.5-11 Space Station Summary, Acquisition Costs 1984$ Millions

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Figure 3.5-12 depicts the personnel projections and annual costs of the O&S phase of the system life cycle. Cost computations were based on the following simplifying assumptions:

- IOC for the LEO space station is 1990. This marks the start of the 10-year O&S phase
- O&S excludes mission related support activities
- Ground personnel works 8-hour shifts, 250 days/year
- Space crew tour of duty is 10 years
- Space crew works 8-hour shifts, 180 days/year. The 8 hours are divided into 6 hours of IVA, 3.5 hours of scheduled EVA, and 0.5 hours of non-scheduled EVA
- Labor rates are:
  - ground personnel - 30 $/hr
  - IVA - 900 $/hr
  - Scheduled EVA - 2400 $/hr
  - Non-scheduled EVA - $96000 + 16000 $/hr
- Resupply shuttle flights to replace logistics modules occur in three-month intervals throughout the O&S phase
- Cost of consumables is arbitrarily set at $250/kg, excluding system spares.

PERSONNEL/COSTS	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	TOT
SPACE CREW	–	–	6	9	9	12	16	20	24	24	24	24	24	24	24	
REAL TIME GND SUPT STAFF			25	25	25	25	25	25	25	25	25	25	25	25	25	
TRAINING STAFF			40	40	40	45	45	50	50	50	50	50	50	50	50	
SUB-TOTAL $			28	40.1	40.1	52.4	68.5	84.9	101	→	→	→	→	→	101	1021
RESUPPLY SHUTTLE FLTS @ 4 PER YR ($M)					143	→	→	→	→	→	→	→	→	→	143	1573
CONSUMABLES $					1	1.	1.	1.5	→	→	→	→	→	→	1.5	15
TOTAL $			28	40.1	184.1	196.4	212.5	229.4	245.5	→	→	→	→	→	245.5	2609

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Fig. 3.5-12 LEO Space Station O & S Cost Projection (1984$ Millions)

4 - PROGRAMMATICS AND FUNDING

This section presents programmatics and funding options for an evolved Space Station. Evolution begins with emplacement of an Initial Space Station in 1990 or 1991. That station is assembled from discrete modules (3-man habitat, external subsystem module, etc) according to Fig. 4.1-1, and grows to its mature configuration by acquiring additional modules plus supporting element modules like the Tended Industrial Platform, Space-based OTV, etc.

4.1 PROGRAMMATICS

While the Space Station can be built with 1983 technology, it will be more efficient if certain enhancing technologies are funded. These technologies will bring online a comprehensive Data Management System, a space-based OTV, Satellite Servicing Equipment, etc that will convert the Space Station from a merely feasible concept to an economically viable tool for Science, Manufacturing and Security. The costs presented in this volume describe a point design for the Space Station, worked out to the subsystem level within the modules. Additional costs are estimated for certain supporting elements. No attempt has been made to put a price on the enhancing technology developments or payloads.

Based on experience with many aircraft development programs (which average less than two years from ATP to first flight) and with LM and the Space Shuttle (about 8 years) it seems reasonable to allow four to five years for the Space Station C/D effort. Figure 4.1-2 presents our Baseline Schedule for Space Station Development based on this assumption. The basic points in this plan are:

- Early funding of a study to define the Space Station Mission explicitly, including firm identification of enhancing technologies that should be funded
- A Program Definition study for the Space Station alone (ØB)
- A phase C/D effort on the Space Station, beginning about 1987 and leading to a launch of the Initial Space Station in 1990
- A six-year evolution of the Space Station to its mature configuration

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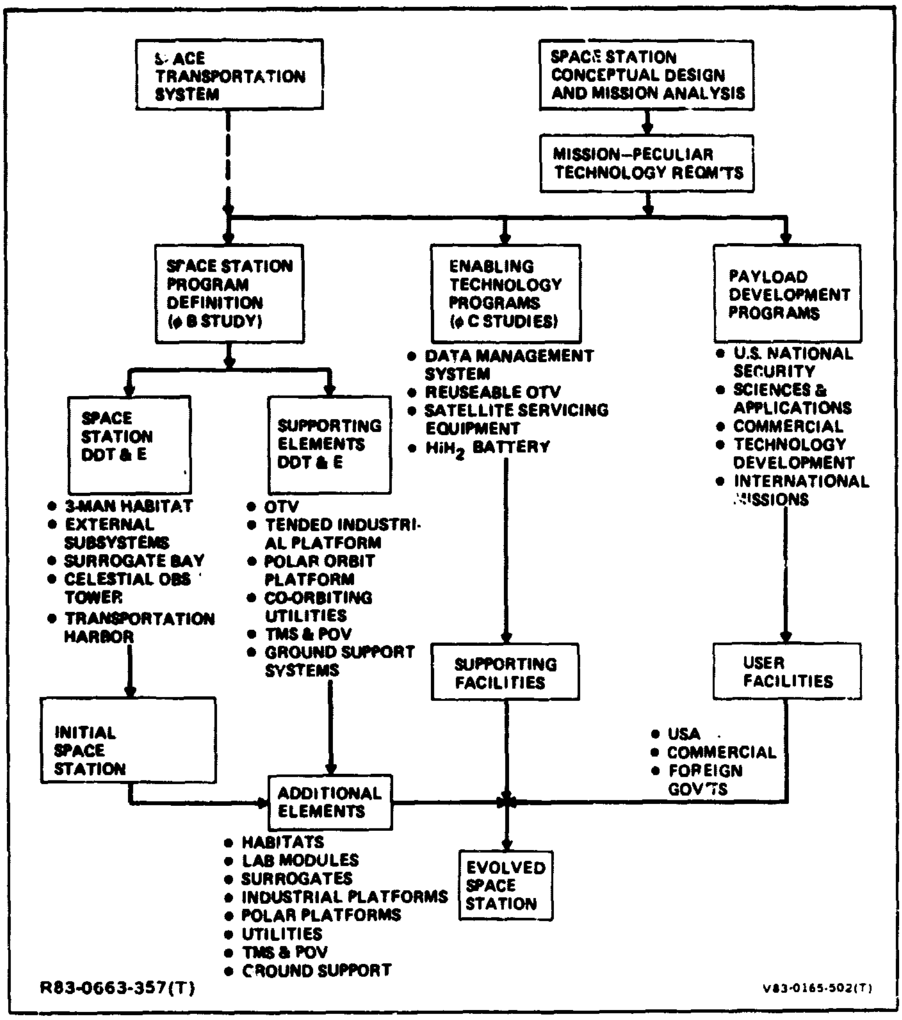

Fig. 4.1-1 Space Station Evolution Flow Chart

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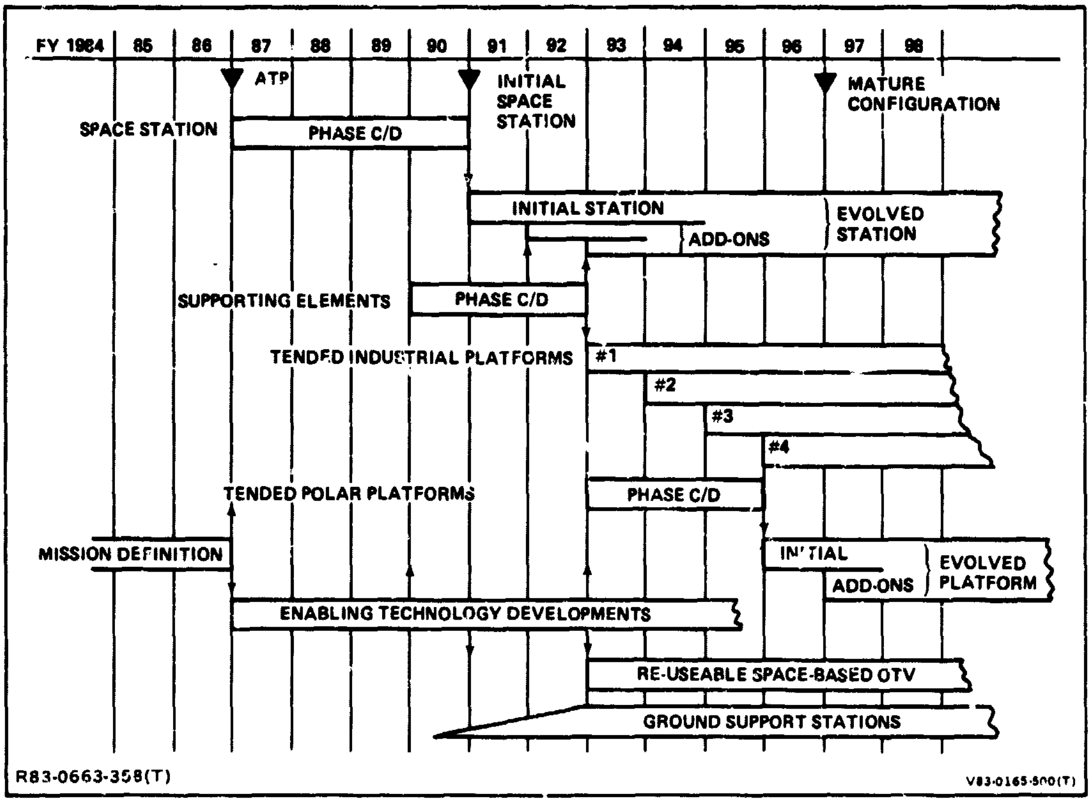

Fig. 4.1-2 Space Station Development Baseline Schedule

- Development of necessary tools, such as Ground Support Stations and Satellite Servicing tools, by funding the necessary technologies.

4.2 FUNDING OPTIONS

A funding profile for the above-described activity is given in Fig. 4.2-1. The estimated total cost for the Space Station alone is $4.278B. Allowing for a reasonable buildup and decline of staffing, this program peaks at about $1.3B. There is some sentiment extant for a Peak Annual Funding (PAF) limit of about $1B. This can be obtained by delaying funding on some element of the program. We have shown an option which delays the Initial Space Station launch to 1991, thereby reducing PAF on the largest element. This slips the program 1 year (see Fig. 4.2-2).

In our Baseline Schedule we show that the Initial Space Station can be doing useful work (using onboard laboratories) while providing a harbor for the Space Shuttle and one-shot OTVs by 1990. The supporting elements should be put in place as soon afterward as possible while observing the $1B PAF limit. First choice falls on the co-orbiting Tended Industrial Platforms, because they show the greatest potential for payback. After a few of them are in place we can install the Polar-orbiting Platform (once again observing the $1B PAF limit). The re-useable space-based OTV will be needed about 3 years after the Space Station becomes operational; Ground Support Stations will be needed earlier. We believe that all necessary equipment can be put in place within 10 years of the decision to proceed, thereby providing a mature and useful Space Station complex about 1996.

4.3 COMMERCIAL/FOREIGN PARTICIPATION

While examining the projected cost for producing the initial Space Station consideration was given to the proposition that some parts of the station might be "farmed out" to large contractors, a consortium, or to foreign interests who would finance and develop these parts or modules, to be repayed with a lease or barter arrangement.

We made the rather arbitrary assumption that NASA would retain responsibility and control of the $1B-class modules; Habitat ($2088M), and External Subsystem ($974M), because we felt that an industrial contractor or consortium would not be

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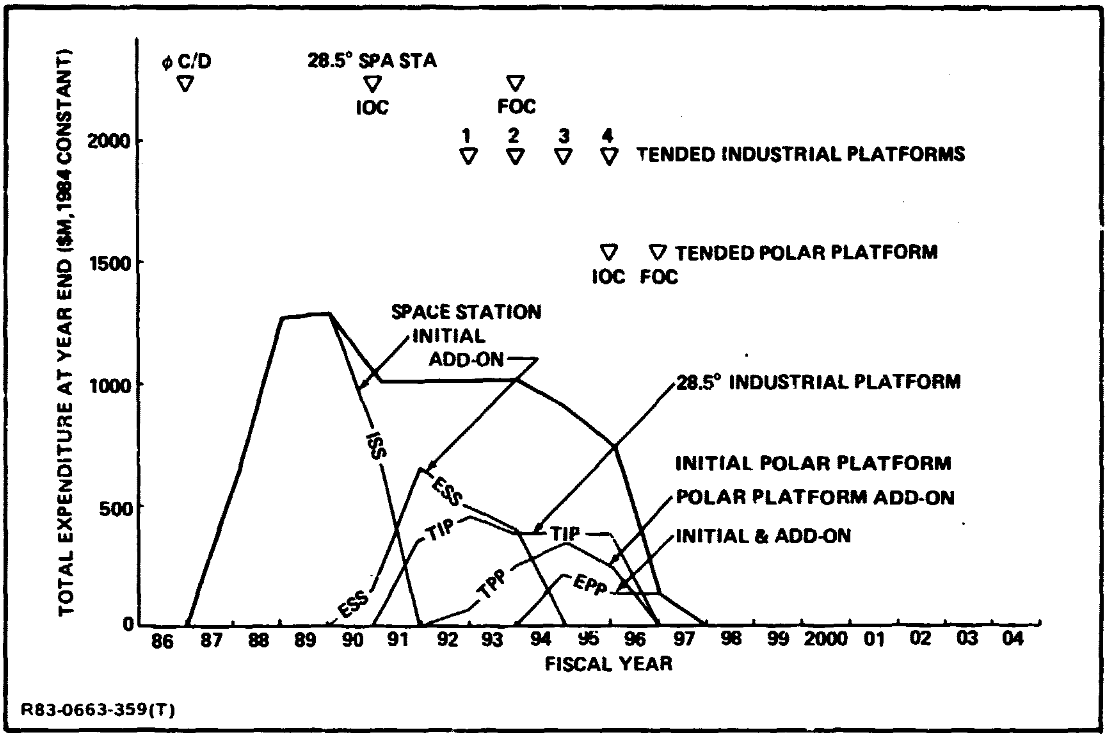

Fig. 4.2-1 Space Station Funding Profile for Initial Station in 1990

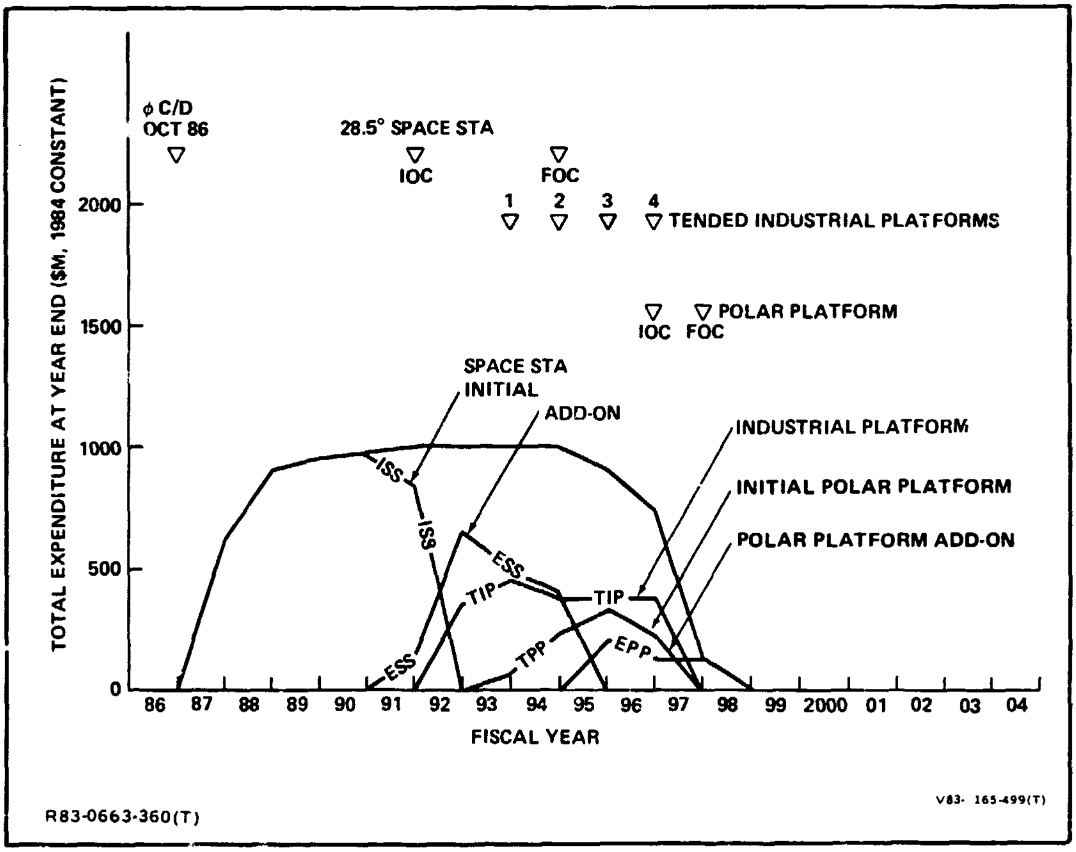

Fig. 4.2-2 Space Station Funding Profile for $1B PAF

likely to consider it an attractive investment due to the large investment required and the risks involved.

The logistics module ($328M), the observation module ($208M), and the surrogate module ($498M) appear to be within the financial capability of large aerospace contractors, or a consortium of them. To reduce the NASA "up front" cost, we think it feasible for such a contractor or consortium to design, qualify and build these modules, then lease them to NASA for operation.

This scheme has the potential of offloading $1034M from the NASA Investment. It must be observed, however, that lease costs would increase operating costs by a considerable amount. Making a very crude approximation, costs would rise $30 per $100 invested, thus, NASA would have to pay back the investment cost in slightly more than 3 years. The contractor would recoup his investment (after taxes) in about 6 years, which is about as long as any entrepreneur would find attractive.

A more modest proposition would be to develop such participation in the supply of "detachable" hardware, such as berthing ports, pallets, airlocks, etc. A total potential offload of $156M is available using this scheme. Using both approaches, a total potential reduction of NASA Investment of $1104M might be realized. (Note that of the detachable hardware potential of $156M, $86M is already in potential contractor-supplied modules, hence only $70 is left as offload.)

Figure 4.3-1 illustrates this approach in block diagram form.

It is clear that foreign governments or contractors might participate in a program of this kind on a lease, offset, or barter agreement.

Another approach merits consideration. Let us assume that the initial cluster is contracted out as shown in Fig. 4.3-2, with contractor "A" producing the pressure vessel (Habitation Modules). The follow-on pressure vessels should be structurally identical, therefore this contractor would have the know-how and personnel to produce all of the follow-on pressure vessels. That contractor might be willing to invest his own funds in building and leasing some, or all of the follow-on units.

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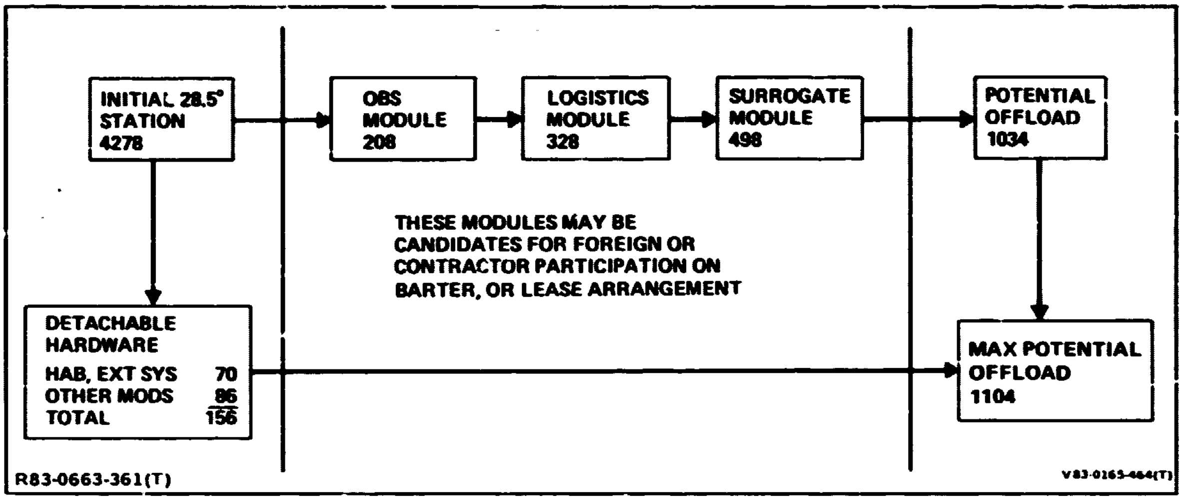

Fig. 4.3-1 Initial Space Station (28.5°) Progr~n Options Acquisition Cost, FY 1984$ (Millions)

CONTRACTOR	ELEMENT		BASIC STATION INITIAL	BASIC STATION ADD-ON	TENDED INDUST PLATFORM	TENDED PLTFM	POLAR
A	PRESSURE VESSELS	• 3 CREW HAB • LAB • M.P.S. VESS	2088	523 485	404 + 4 x 123	261	4253
B	EXTERNAL SUBSYSTEMS OBSERV	• BASIC 22 KW • 44 KW ADD-ON • TOWER	975 208	421	4 x 202	202 58	2672
C	SURROG BAY	• 30' UNIT	489	91		60	640
D	LOGISTICS MOD		328				328
E	OTV			752			752
			4088	2272	1704	581	8645

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Fig. 4.3-2 Contractor Costs ($M 84) – No Transport Charges – No NASA Wraparound

This will reduce the NASA "up front" cost, remembering the caveat mentioned above regarding the adverse impact on operating costs.

Since the Initial Station Habitation Module will be a $2.1B effort, it does not seem unreasonable to think that a contractor would be willing to invest a substantial sum (at low risk as far as technological problems are concerned). The pressurized module follow-on work has a potential contractor participation value of another $2.1M. In the case of the External Subsystems, the initial contract will be about $1.2B, with a follow-on investment or offload potential of $0.9B. The initial contract for the Surrogate Bays, will be for about $0.5B, with a follow-on potential $0.2B. The Logistics Module, at $0.3B is a prime candidate for contractor self-financed construction and operation. The OTV, at $0.7B is another possibility for both construction and operation by private financing (Fig. 4.3-3).

MODULE	DDT & E	NO. OF UNITS	PRODUCTION	TOTAL
PROPULSION	430	1	55	485
VEHICLE	249	1	18	266
TOTAL	679		73	752
R83-0663-363(T)			REF. 317-1	

Fig. 4.3-3 Data Form A Storable OTV (FY '84$ Millions)

5 - ACCRUED BENEFITS ANALYSIS

5.1 INTRODUCTION

Benefits have been assessed in as quantitative a manner as possible.

Benefits have been catagorized here as economic, military, performance and social. Each category is described below.

5.2 ECONOMIC BENEFITS

Most Space Station users can look forward to an economic benefit. A larger group, potentially the whole country, may reap performance and social benefits.

Six activities that yield economic benefits were investigated. For each of the six, the cost of the Space Station way of performing the task is compared with the lowest cost non-Space Station method, and the cumulative savings are plotted through the year 2000. The Space Station investment to support the activity is also shown and the cross-over point marked with a small circle. The excess of savings over investment is the net benefit.

The economic benefit analysis was performed by calculating the incremental investment required to provide each operating facility of the Space Station (i.e., R&D facility, Service/assembly facility, Transport Harbor and Observatory and the platforms). For typical missions, costs were estimated using the Space Station, and by the best non-Space Station means. The benefit was considered to be the difference between the two costs. The benefits were then accrued according to the mission model plan.

For the commercial missions, the combined resources of Grumman, General Electric and COMSAT General were utilized to develop a candidate list of missions/processes that were marketable and for which benefits analyses could be quantified.

When considering the Science and Application missions, the Space Operations Center (SOC) mission model was used to identify the candidate list of free-flying satellite missions. To this was added the sortie-type missions that required pressurized volume (internally mounted) and those that could be mounted externally on the Space Station structure.

Approximately 90 missions/payloads were considered for this model. Of the 90 missions, 62 were selected for inclusion in the Space Station Baseline Mission Model. These 62 Baseline missions are identified in Section 2, Volume, I, Book 1.

The commercial mission must show a reasonable return on investment or a private party will not engage in the venture. The criteria for selection of commercial mission candidates in the 1990 decade involved:

- Introduction of a new or improved product or service by utilizing space
- Projected market value of the product
- Estimated costs of production.

Products must have a very high market value because space-related costs usually will be high relative to ground costs. For instance, the transport of materials to low earth orbit by the STS in the 90s is estimated to cost approximate $2500 per kg ($84.1M each flight/34,000 kg). Assuming the total cost will be at least double the transport cost, and realizing the uncertainty of the projections in the 1990 time-frame, the candidate product or service must sell for well more than $5000/kg.

In addition to the above criteria for each mission, the incremental benefits of the Space Station must be assessed relative to potential alternatives. All of the missions presented in this subsection benefit from using a Space Station, but in varying degree. The benefits have been quantified by relative costs for the missions indicated. The relative costs were determined using simplified calculations which are included in each mission subsection of Volume 1, Book 1. The simplified procedures, although subjective and not completely detailed, are believed commensurate with the scope of the study. Space Station program costs have been excluded from the cost comparisons for individual missions. The Space Station costs are compared to the accrued benefits from all the selected missions.

Figure 5-1 summarizes the costs and benefits for the economic situations analyzed here. The payback period (the crossover of investment against benefits) is denoted by a small circle.

In the case of the Transport Station Fig. 5-1 for example, the recurring cost of transporting the expected manifest of civil and military communication satellites to geosynchronous orbit averages $318M less per year when using a space-based reusable OTV, than when using the otherwise best available method, expendable SRMS and Centaurs. The gross savings from 1993, when the Transport Harbor is assumed to start operations, through year 2000, amounts to $2550M. The added Space Station cost to provide the service is $240M and the net OTV costs $820M giving a total investment of $1060M. The payback period is just over three years; the net benefit by the year 2000 is $1490M.

The Tended Platforms, Industrial Park and Tended Polar Platform show very acceptable payoffs (six and four years, respectively). Benefit of the Industrial Platform may be expected to continue to rise as experience is gained in it use, and a broader constituency is developed.

The observatory accrued benefit is not expected to exhibit the exponential growth shown by the Industrial Park, but is expected to be more stable. It shows a quite satisfactory payback in five years.

The test facility was found to have a very rapid payoff (two years) when military and civil missions were considered. The Transport Harbor payoff is also quite fast (three years), and is expected to continue to rise as traffic develops.

The service/assembly shows less spectacular, though quite satisfactory payback characteristics of four years.

5.3 MILITARY SPACE STATION FUNCTIONS WITH HIGH PAYBACK

As the accrued benefit analysis shows, the most attractive Space Station capabilities for the military are the test laboratory/test range facility and the space-based OTV.

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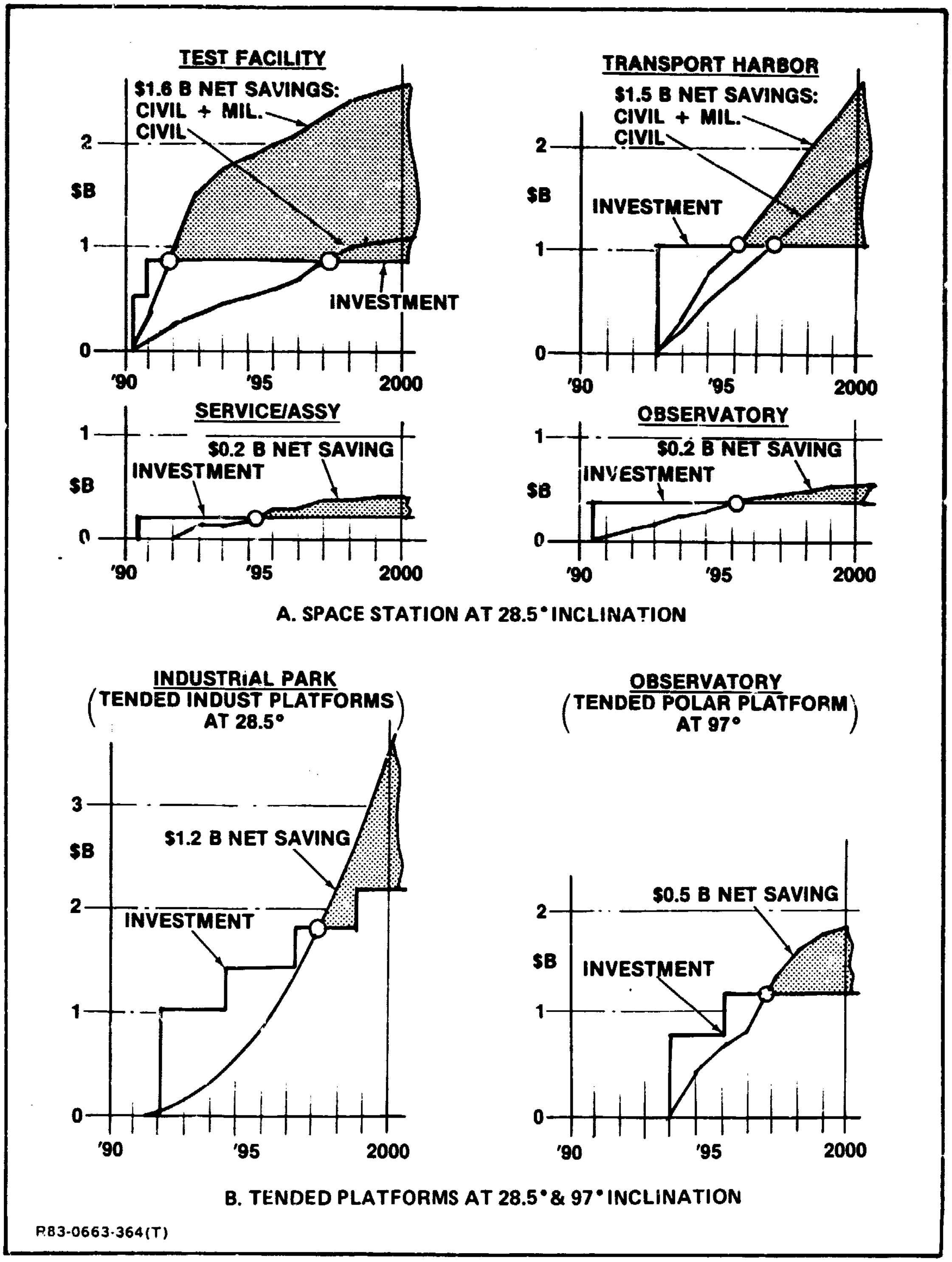

Fig. 5-1 Accrued Economic Benefits

The former yields a significant decrease in development time and cost for military developments, and the latter offers significant savings in transport from LEO to high-inclination orbit or GEO. Figure 5-2 summarizes these gains.

5.4 PERFORMANCE BENEFITS

All mission operations will benefit from the reduced impact on mission operations caused by Shuttle reschedules, payload priorities, or delays (see Fig. 5-3). This will be especially significant as the Station matures and develops its full capability of crew and equipment.

We anticipate that the current trend of making larger satellites will be encouraged by the capability of lifting large payloads to GEO; such satellites will be designed with that in mind.

The on-orbit assembly capability affords an economical method for very large structures without Shuttle-size limitations, excessive Shuttle loiter time, and extensive EVA activities.

In two of our studies, development programs were reduced 50% by Space Station use.

5.5 SOCIAL BENEFITS

The social/societal benefits to be expected from implementation of a viable Space Station program, although difficult to quantify in precise terms, are nontheless real, important, and of considerable magnitude. These benefits are summarized in Fig. 5-4.

This nation has been in the forefront of high technology development which is an implicit and explicit national goal. The Space Station augments the national capabilities for high technology in a very significant manner, and provides a focus for what some feel is our lagging engineering and science educational aims.

International cooperation has been generated by the shuttle program, and the Space Station can provide a much greater and broader stimulation for international cooperation.

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DoD INVOLVEMENT AS ON SPACE SHUTTLE

STATION CAPABILITY	MISSION	PAY-BACK
▷ NATIONAL SPACE TEST FACILITY & RANGE	• ENGINEERING DEV • PROOF OF CONCEPT	26% OF SPACE TEST COSTS SAVED
▷ TRANSPORT HARBOR & SPACE-BASED OTV	• SATELLITE DEPLOY-MENT TO GEO	PAYBACK IN > 4 YEARS, CIVIL/MILITARY TRAFFIC

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Fig. 5-2 Military Space Station Functions With High Payback

▷ALL MISSION OPERATIONS	• DECOUPLED FROM SHUTTLE LAUNCH SCHEDULE, PAYLOAD PRIORITIES, & GROUND DELAYS
▷SPACE BASED OTV	• 10,000 kg + USEFUL PAYLOAD INTO GEO • ON-DEMAND CAPABILITY
▷ON-ORBIT ASSEMBLY	• ASTRONAUT CAN INSPECT, WORK AROUND, & COMPLEMENT ROBOTICS & AUTOMATION • SHUTTLE SIZE LIMITS SURMOUNTED
▷ON-ORBIT TECHNOLOGY AND R&D	• ASTRONAUT CAN CALIBRATE, OPERATE, & MODIFY • TRUE SPACE ENVIRONMENT • INTERACTION OF MULTIPLE DISCIPLINES & CAPABILITIES IN A NOVEL ENVIRONMENT WILL PRODUCE SYNERGISTIC ADVANCES • SHORTER DEVELOPMENT PROGRAMS
▷SCIENTIFIC OBSERVATIONS	• SHORT LIVED EXPERIMENTS EXTENDED • ASTRONAUT CAN MONITOR, INTERVENE, REPLENISH, & UPDATE.

R83-0663-366(T) V83-0165-943(T)

Fig. 5-3 Performance Benefits

IN THE SHORT TERM:	
• HI-TECH – A NATIONAL GOAL	• UNIQUE, AFFORDABLE DEVELOPMENT FACILITY
• FOCUS FOR ENGINEERING/ SCIENCE EDUCATION	• NEW COMMUNICATION SERVICES
• UNIQUE LUNAR & BEYOND EXPLORATION	• NEW COMMERCIAL PRODUCTS & INDUSTRIES – MEDICAL, SEMI-CONDUCTOR
• INTERNATIONAL COOPERATION	• NEW THERAPEUTIC, DIAGNOSTIC TECHNIQUES
	• ENHANCED NATIONAL SECURITY
IN THE LONG TERM:	
• GATEWAY TO THE FUTURE	
R83-0663-367(T)	V83-0165-944(T)

Fig. 5-4 Social Benefits

In terms of a unique development facility, there can be no earth-bound parallel. The possibilities for development of communication services, commercial products, and industries in the semiconductor and medical fields, are all realizable benefits.

New therapeutic and diagnostic techniques have been demonstrated by limited Shuttle experiments, with a Space Station offering vastly augmented capabilities. The Space Station may well represent the military "high ground" required for our security.

These near-term benefits lead to the inevitable conclusion in the long-term, that the Space Station is truly the "gateway to the future."

ORIGINAL PAGE IS
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APPENDIX A

DETAILED COST RUNS

***** NOTES ON SPACE MODEL INPUTS *****

THIS TABLE LISTS ONLY THOSE WBS ITEMS WHICH ARE COSTED BY $ THRUPUT AND/OR PARAMETRIC COST DRIVERS
WHEN INPUTS ARE DOLLAR THRUPUTS; COL. 1 IS FOR DDT&E, COL. 2 IS FOR PRODUCTION, COL. 3 IS FOR OPERATIONS
WHEN INPUTS ARE WTS SPECIFIED AS KG,KG; COL. 1 IS FOR NON-REPLICATED WT, COL. 2 IS FOR TOTAL DRY WT.
WHEN INPUTS ARE WTS SPECIFIED AS KG; COL. 1 IS FOR TOTAL DRY WT.
QUANTITY PFU = PER FIRST UNIT, TOT = TOTAL PROD. QTY
COMMONALITY FACTOR 1 = NO COST REDUCTION DUE TO COST SHARING 0 = 100% COST REDUCTION DUE TO COMMONALITY
COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

INITIAL CLUSTER INPUTS---- MODE **RUN 37-1**

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMN DDT&E	COMPLEXITY DDT&E	TFU	SODEV DDT&E
4	10.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
6	10.1.1.2.1	STRUCTURE	KG	3650.00	0.0	0.0	0.0	1	1	1.00	0.60	0.59	1.00	0.73	0.80
7	10.1.1.2.2	BERTHING	KG	400.00	0.0	0.0	0.0	6	6	1.00	0.0	0.0	1.00	1.00	1.00
7	10.1.1.2.2	BERTHING	DLR	0.0	0.500	0.0		6	6	1.00	0.0				
8	10.1.1.2.3	EPS	KG,KG	50.00	50.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	0.50
11	10.1.1.2.4	ECLS	KG,KG	1314.00	1314.00	0.0	0.0	1	1	1.00	0.60	0.82	0.90	1.00	0.90
12	10.1.1.2.5	THERMAL CONTROL	KG	670.00	0.0	0.0	0.0	1	1	1.00	0.60	0.40	1.00	0.80	0.80
166	10.1.1.2.6	CONTR & DISPL	KG	140.00	0.0	0.0	0.0	1	1	1.00	0.60	0.45	1.00	1.00	0.80
14	10.1.1.2.8	DATA MGMT	KG,KG	510.00	510.00	0.0	0.0	1	1	1.00	0.60	0.50	1.00	1.00	0.80
15	10.1.1.2.9	COMMUNICATION	KG,KG	550.00	550.00	0.0	0.0	1	1	1.00	0.60	0.50	1.00	1.00	0.80
16	10.1.1.2.10	GN&C	KG,KG	120.00	120.00	0.0	0.0	1	1	1.00	0.60	0.40	1.00	1.00	0.80
17	10.1.1.2.11	CREW ACCOMM	KG,KG	1050.00	1050.00	0.0	0.0	1	1	1.00	0.60	0.87	1.00	0.80	0.50
169	10.1.1.2.12	TUNNEL	KG	250.00	0.0	0.0	0.0	2	2	1.00	0.60	1.00	1.00	0.90	0.90
20	10.1.2	SOFTWARE	DLR	150.000	0.0	0.0		1	1	1.00	0.0				
19	10.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
31	50.1.1.2.1	STRUCTURE	KG	1050.00	0.0	0.0	0.0	1	3	1.00	0.0	0.70	1.00	0.70	0.80
32	50.1.1.2.2	BERTHING	KG	68.00	0.0	0.0	0.0	1	3	1.00	0.0	1.00	1.00	1.00	0.0
32	50.1.1.2.2	BERTHING	DLR	0.0	0.500	0.0		1	3	1.00	0.0				
33	50.1.1.2.3	PALLET	KG,KG	582.00	0.0	0.0	0.0	1	3	1.00	0.0	1.00	1.00	1.00	0.0
33	50.1.1.2.3	PALLET	DLR	0.0	8.870	0.0		1	3	1.00	0.0				
98	30.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
100	30.1.1.2.1	STRUCTURE	KG	964.00	0.0	0.0	0.0	1	1	1.00	0.60	0.50	0.70	0.70	0.70
174	30.1.1.2.3	EPS	KG,KG	50.00	50.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	0.50
102	30.1.1.2.4	THERMAL CONTROL	KG	100.00	0.0	0.0	0.0	1	1	1.00	0.60	0.40	1.00	0.80	0.80
10	30.1.1.2.5	DATA MGMT	KG,KG	25.00	25.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	0.80
103	30.1.1.2.6	RMS	DLR	0.0	10.000	0.0		1	1	1.00	0.0				
104	30.1.1.2.7	HPA	DLR	0.0	10.680	0.0		1	1	1.00	0.0				
105	30.1.1.2.8	OCP	DLR	0.0	3.220	0.0		1	1	1.00	0.0				
106	30.1.1.2.9	POM	DLR	0.0	7.500	0.0		1	1	1.00	0.0				
181	30.1.1.2.10	TELE END EFF	DLR	0.0	4.000	0.0		1	1	1.00	0.0				
108	30.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
118	70.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
120	70.1.1.2.1	STRUCTURE	KG	200.00	0.0	0.0	0.0	1	1	1.00	0.60	0.60	0.70	0.70	0.70
121	70.1.1.2.2	IPS	KG	1160.00	0.0	0.0	0.0	1	1	1.00	0.0	1.00	1.00	1.00	0.0
121	70.1.1.2.2	IPS	DLR	0.0	13.350	0.0		1	1	1.00	0.0				
121	70.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
137	20.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
139	20.1.1.2.1	PALLET	KG	582.00	0.0	0.0	0.0	1	1	1.00	0.0	0.33	1.00	0.90	0.0
139	20.1.1.2.1	PALLET	DLR	0.0	8.870	0.0		1	1	1.00	0.0				
205	20.1.1.2.2	TOWER	KG	730.00	0.0	0.0	0.0	2	2	1.00	0.60	0.30	1.00	0.90	1.00
206	20.1.1.2.3	GIMBAL	KG	1000.00	0.0	0.0	0.0	1	1	1.00	0.60	0.80	1.00	0.90	1.00
141	20.1.1.2.5	EPS	KG,KG	1140.00	1140.00	0.0	0.0	1	1	1.00	0.60	0.18	1.00	1.00	0.80
142	20.1.1.2.6	SOLAR ARRAY	WATTS	48000.00	0.0	0.0	0.0	1	1	1.00	0.60	0.17	1.00	1.00	0.80
175	20.1.1.2.7	RCS	KG,KG	340.00	340.00	0.0	0.0	1	1	1.00	0.60	0.40	1.00	1.00	0.80
143	20.1.1.2.8	GN&C	KG,KG	380.00	380.00	0.0	0.0	1	1	1.00	0.60	0.40	1.00	1.00	1.00
144	20.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
185	90.0	AIRLOCK	DLR	0.0	19.250	0.0		1	1	1.00	0.0				
207	80.0	TRANSPORTATION	DLR	0.0	84.100	0.0		2	2	1.00	0.0				

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE FFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED, PROFIT EXCLUDED

INITIAL CLUSTER LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

WBS	COST ELEMENT	DDT&E: ENG DES AND DEV	DDT&E: GRD TEST HDWR	DDT&E: TOTAL	PRODUCTION: FIRST UNIT	PRODUCTION: VEHICLE PROD	PRODUCTION: INITIAL SPARES	PRODUCTION: TOTAL	OPERATIONS: OPER	OPERATIONS: OPER SPARES	OPERATIONS: TOTAL	TOTAL
1.0	SPACE STATION	3164.66	254.32	3418.98	760.80	797.42	61.81	859.23	0.0	0.0	0.0	4278.21
10.0	HABITAT 3MAN	1702.05	124.34	1826.39	235.57	235.57	25.65	261.22	0.0	0.0	0.0	2087.61
10.1	SPACECRAFT SEG	1445.00	124.34	1569.34	235.57	235.57	25.65	261.22	0.0	0.0	0.0	1830.56
10.1.1	HARDWARE	839.94	116.20	956.13	196.66	196.66	25.65	222.31	0.0	0.0	0.0	1178.44
10.1.1.1	IACO	79.10	15.39	94.49	25.65	25.65	0.0	25.65	0.0	0.0	0.0	[illegible]
10.1.1.2	SUBSYSTEMS	760.84	100.80	861.65	171.01	171.01	25.65	196.66	0.0	0.0	0.0	1058.30
10.1.1.2.1	STRUCTURE	68.80	9.68	78.48	16.14	16.14	2.42	18.56	0.0	0.0	0.0	97.04
10.1.1.2.2	BERTHING	0.0	0.0	0.0	3.00	3.00	0.45	3.45	0.0	0.0	0.0	3.45
10.1.1.2.3	EPS	4.45	0.96	5.41	1.60	1.60	0.24	1.84	0.0	0.0	0.0	7.25
10.1.1.2.4	ECLS	210.96	26.03	236.98	43.38	43.38	6.51	49.88	0.0	0.0	0.0	286.56
10.1.1.2.5	THERMAL CONTROL	3.30	4.82	8.12	8.03	8.03	1.20	9.24	0.0	0.0	0.0	17.36
10.1.1.2.6	CONTR & DISPL	10.91	1.63	12.54	2.72	2.72	0.41	3.13	0.0	0.0	0.0	15.66
10.1.1.2.8	DATA MGMT	182.34	19.19	201.33	31.99	31.99	4.80	36.78	0.0	0.0	0.0	238.32
10.1.1.2.9	COMMUNICATION	190.49	20.57	211.06	34.28	34.28	5.14	39.42	0.0	0.0	0.0	250.48
10.1.1.2.10	GN&C	4.10	3.87	7.97	6.46	6.46	0.97	7.43	0.0	0.0	0.0	15.39
10.1.1.2.11	CREW ACCOMM	50.33	6.71	57.04	11.19	11.19	1.68	12.87	0.0	0.0	0.0	69.91
10.1.1.2.12	TUNNEL	35.17	7.34	42.51	12.23	12.23	1.83	14.06	0.0	0.0	0.0	56.56
10.1.2	SOFTWARE	150.00	0.0	150.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	150.00
10.1.3	SERVICES	278.05	8.15	286.19	38.91	38.91	0.0	38.91	0.0	0.0	0.0	325.10
10.1.3.1	SE&I	135.95	0.0	135.95	21.40	21.40	0.0	21.40	0.0	0.0	0.0	157.35
10.1.3.2	PM	78.39	8.15	86.54	13.58	13.58	0.0	13.58	0.0	0.0	0.0	100.12
10.1.3.3	OTHER	63.70	0.0	63.70	3.93	3.93	0.0	3.93	0.0	0.0	0.0	67.63
10.1.5	GSE	177.02	0.0	177.02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	177.02
10.4	INT&TST SYS LEV	257.05	0.0	257.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	257.05
50.0	LOGISTICS MOD	260.32	0.0	260.32	28.48	65.10	2.75	67.85	0.0	0.0	0.0	328.17
50.1	SPACECRAFT SEG	203.04	0.0	203.04	28.48	65.10	2.75	67.85	0.0	0.0	0.0	270.89
50.1.1	HARDWARE	83.87	0.0	83.87	22.31	58.94	2.75	61.68	0.0	0.0	0.0	145.55
50.1.1.1	IACO	39.59	0.0	39.59	4.00	4.00	0.0	4.00	0.0	0.0	0.0	43.59
50.1.1.2	SUBSYSTEMS	44.28	0.0	44.28	18.31	54.94	2.75	57.69	0.0	0.0	0.0	[illegible]
50.1.1.2.1	STRUCTURE	44.28	0.0	44.28	8.94	26.83	1.34	[illegible]	0.0	0.0	0.0	72.45
50.1.1.2.2	BERTHING	0.0	0.0	0.0	0.50	1.50	0.07	[illegible]	0.0	0.0	0.0	[illegible]
50.1.1.2.3	PALLET	0.0	0.0	0.0	8.87	26.61	1.33	27.94	0.0	0.0	0.0	27.94
50.1.3	SERVICES	57.73	0.0	57.73	6.17	6.17	0.0	6.17	0.0	0.0	0.0	63.89
50.1.3.1	SE&I	27.16	0.0	27.16	3.33	3.33	0.0	3.33	0.0	0.0	0.0	30.48
50.1.3.2	PM	20.44	0.0	20.44	2.39	2.39	0.0	2.39	0.0	0.0	0.0	22.83
50.1.3.3	OTHER	10.13	0.0	10.13	0.45	0.45	0.0	0.45	0.0	0.0	0.0	10.58
50.1.5	GSE	61.45	0.0	61.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.45
50.4	INT&TST SYS LEV	57.28	0.0	57.28	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.28
30.0	SURROGATE	399.76	14.60	414.36	68.01	68.01	6.93	74.94	0.0	0.0	0.0	489.31
30.1	SPACECRAFT SEG	293.09	14.60	307.69	68.01	68.01	6.93	74.94	0.0	0.0	0.0	382.63
30.1.1	HARDWARE	128.94	11.66	140.60	54.83	54.83	6.93	61.76	0.0	0.0	0.0	202.37
30.1.1.1	IACO	52.73	5.18	57.91	8.63	8.63	0.0	8.63	0.0	0.0	0.0	66.55
30.1.1.2	SUBSYSTEMS	76.21	6.48	82.69	46.20	46.20	6.93	53.13	0.0	0.0	0.0	135.82
30.1.1.2.1	STRUCTURE	6.14	2.63	8.76	4.38	4.38	0.66	5.03	0.0	0.0	0.0	13.80
30.1.1.2.3	EPS	4.45	0.96	5.41	1.60	1.60	0.24	1.84	0.0	0.0	0.0	7.25

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OF POOR QUALITY

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE FFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED,PROFIT EXCLUDED

INITIAL CLUSTER LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
30.1.1.2.4	THERMAL CONTROL	2.00	1.68	3.68	2.81	2.81	0.42	3.23	0.0	0.0	0.0	6.91
30.1.1.2.5	DATA MGMT	63.63	1.21	64.84	2.01	2.01	0.30	2.32	0.0	0.0	0.0	67.15
30.1.1.2.6	RMS	0.0	0.0	0.0	10.00	10.00	1.50	11.50	0.0	0.0	0.0	11.50
30.1.1.2.7	HPA	0.0	0.0	0.0	10.68	10.68	1.60	12.28	0.0	0.0	0.0	12.28
30.1.1.2.8	OCP	0.0	0.0	0.0	3.22	3.22	0.48	3.70	0.0	0.0	0.0	3.70
30.1.1.2.9	POM	0.0	0.0	0.0	7.50	7.50	1.12	8.62	0.0	0.0	0.0	8.62
30.1.1.2.10	TELE END EFF	0.0	0.0	0.0	4.00	4.00	0.60	4.60	0.0	0.0	0.0	4.60
30.1.3	SERVICES	84.10	2.94	87.04	13.18	13.18	0.0	13.18	0.0	0.0	0.0	100.22
30.1.3.1	SE&I	40.05	0.0	40.05	7.18	7.18	0.0	7.18	0.0	0.0	0.0	47.23
30.1.3.2	PM	28.27	2.94	31.21	4.90	4.90	0.0	4.90	0.0	0.0	0.0	36.11
30.1.3.3	OTHER	15.78	0.0	15.78	1.10	1.10	0.0	1.10	0.0	0.0	0.0	16.88
30.1.5	GSE	80.04	0.0	80.04	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.04
30.4	INT&TST SYS LEV	106.68	0.0	106.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	106.68
70.0	OBSERV. MODULE	178.81	4.08	182.89	23.30	23.30	2.22	25.52	0.0	0.0	0.0	208.41
70.1	SPACECRAFT SEG	129.21	4.08	133.29	23.30	23.30	2.22	25.52	0.0	0.0	0.0	158.81
70.1.1	HARDWARE	40.36	2.87	43.23	18.13	18.13	2.22	20.35	0.0	0.0	0.0	63.58
70.1.1.1	IACO	37.05	2.01	39.05	3.35	3.35	0.0	3.35	0.0	0.0	0.0	42.40
70.1.1.2	SUBSYSTEMS	3.32	0.86	4.18	14.78	14.78	2.22	17.00	0.0	0.0	0.0	21.18
70.1.1.2.1	STRUCTURE	3.32	0.86	4.18	1.43	1.43	0.21	1.65	0.0	0.0	0.0	5.82
70.1.1.2.2	IPS	0.0	0.0	0.0	13.35	13.35	2.00	15.35	0.0	0.0	0.0	15.35
70.1.3	SERVICES	40.14	1.22	41.35	5.18	5.18	0.0	5.18	0.0	0.0	0.0	46.53
70.1.3.1	SE&I	17.71	0.0	17.71	2.79	2.79	0.0	2.79	0.0	0.0	0.0	20.49
70.1.3.2	PM	15.49	1.22	16.71	2.03	2.03	0.0	2.03	0.0	0.0	0.0	18.74
70.1.3.3	OTHER	6.93	0.0	6.93	0.36	0.36	0.0	0.36	0.0	0.0	0.0	7.30
70.1.5	GSE	48.71	0.0	48.71	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.71
70.4	INT&TST SYS LEV	49.60	0.0	49.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	49.60
20.0	EXT. SUBSYSTEMS	623.72	111.30	735.02	217.99	217.99	21.37	239.36	0.0	0.0	0.0	974.38
20.1	SPACECRAFT SEG	380.34	111.30	491.64	217.99	217.99	21.37	239.36	0.0	0.0	0.0	731.00
20.1.1	HARDWARE	151.50	103.65	255.16	181.62	181.62	21.37	203.00	0.0	0.0	0.0	458.16
20.1.1.1	IACO	77.13	14.38	91.51	23.97	23.97	0.0	23.97	0.0	0.0	0.0	115.49
20.1.1.2	SUBSYSTEMS	74.38	89.27	163.65	157.65	157.65	21.37	179.03	0.0	0.0	0.0	342.67
20.1.1.2.1	PALLET	0.0	0.0	0.0	8.87	8.87	1.33	10.20	0.0	0.0	0.0	10.20
20.1.1.2.2	TOWER	6.60	5.63	12.23	9.38	9.38	0.0	9.38	0.0	0.0	0.0	21.61
20.1.1.2.3	GIMBAL	20.43	3.47	23.90	5.78	5.78	0.0	5.78	0.0	0.0	0.0	29.68
20.1.1.2.5	EPS	7.95	11.17	19.12	18.61	18.61	2.79	21.40	0.0	0.0	0.0	40.52
20.1.1.2.6	SOLAR ARRAY	21.35	59.64	80.99	99.40	99.40	14.91	114.31	0.0	0.0	0.0	195.30
20.1.1.2.7	RCS	10.80	2.52	13.31	4.20	4.20	0.63	4.83	0.0	0.0	0.0	18.14
20.1.1.2.8	GN&C	7.25	6.85	14.10	11.41	11.41	1.71	13.12	0.0	0.0	0.0	27.22
20.1.3	SERVICES	124.35	7.65	132.00	36.37	36.37	0.0	36.37	0.0	0.0	0.0	168.36
20.1.3.1	SE&I	59.85	0.0	59.85	19.99	19.99	0.0	19.99	0.0	0.0	0.0	79.84
20.1.3.2	PM	39.53	7.65	47.18	12.74	12.74	0.0	12.74	0.0	0.0	0.0	59.92
20.1.3.3	OTHER	24.97	0.0	24.97	3.63	3.63	0.0	3.63	0.0	0.0	0.0	28.60
20.1.5	GSE	104.48	0.0	104.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	104.48
20.4	INT&TST SYS LEV	243.38	0.0	243.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	243.38
90.0	AIRLOCK	0.0	0.0	0.0	19.25	19.25	2.89	22.14	0.0	0.0	0.0	22.14
80.0	TRANSPORTATION	0.0	0.0	0.0	168.20	168.20	0.0	168.20	0.0	0.0	0.0	168.20
1.1	PROG SPPT	443.05	0.0	443.05	0.0	0.0	0.0	0.0	0.0	0.0	0.0	443.05
1.2	MGMT & INTEG	158.23	0.0	158.23	38.04	38.04	0.0	38.04	0.0	0.0	0.0	196.27
1.3	LAUNCH & LANDING	38.36	0.0	38.36	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.36

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ORIGINAL PAGE IS
OF POOR QUALITY

***** NOTES ON SPACE MODEL INPUTS *****

THIS TABLE LISTS ONLY THOSE WBS ITEMS WHICH ARE COSTED BY $ THRUPUT AND/OR PARAMETRIC COST DRIVERS
WHEN INPUTS ARE DOLLAR THRUPUTS; COL. 1 IS FOR DDT&E, COL. 2 IS FOR PRODUCTION, COL. 3 IS FOR OPERATIONS
WHEN INPUTS ARE WTS SPECIFIED AS KG,KG; COL. 1 IS FOR NON-REPLICATED WT, COL. 2 IS FOR TOTAL DRY WT.
WHEN INPUTS ARE WTS SPECIFIED AS KG; COL. 1 IS FOR TOTAL DRY WT.
QUANTITY PFU = PER FIRST UNIT, TOT = TOTAL PROD. QTY
COMMONALITY FACTOR 1 = NO COST REDUCTION DUE TO COST SHARING 0 = 100% COST REDUCTION DUE TO COMMONALITY
COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

EVOLVED CLUSTER INPUTS---- MODE **RUN 310-1**

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMN DDT&E	COMPLEXITY DDT&E	TFU	SODEV DDT&E
50	10.0	HABITAT 3MEN	DLR	0.0	235.570	0.0		2	2	1.00	0.0				
80	40.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
82	40.1.1.2.1	STRUCTURE	KG	3650.00	0.0	0.0	0.0	2	4	1.00	0.60	0.20	1.00	0.73	0.80
171	40.1.1.2.2	BERTHING	KG	68.00	0.0	0.0	0.0	4	8	1.00	0.0	1.00	1.00	1.00	0.0
171	40.1.1.2.2	BERTHING	DLR	0.0	0.500	0.0		4	8	1.00	0.0				
172	40.1.1.2.3	EPS	KG,KG	120.00	120.00	0.0	0.0	1	2	1.00	0.60	1.00	1.00	1.00	0.50
83	40.1.1.2.4	ECLS	KG,KG	50.00	50.00	0.0	0.0	1	2	1.00	0.60	1.00	0.80	0.50	0.50
84	40.1.1.2.5	THERMAL CONTROL	KG	1500.00	0.0	0.0	0.0	1	2	1.00	0.60	0.22	1.00	0.80	0.80
168	40.1.1.2.6	CONTR & DISPL	KG	40.00	40.00	0.0	0.0	1	2	1.00	0.60	1.00	1.00	1.00	0.80
85	40.1.1.2.7	DATA MGMT/COMM	KG,KG	50.00	50.00	0.0	0.0	1	2	1.00	0.60	0.30	1.00	1.00	0.80
86	40.1.1.2.9	CREW ACCOMM	KG,KG	120.00	120.00	0.0	0.0	1	2	1.00	0.60	0.40	1.00	0.60	0.40
88	40.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
100	30.1.1.2.1	STRUCTURE	KG	964.00	0.0	0.0	0.0	1	3	1.00	0.0	0.0	0.70	0.70	0.70
174	30.1.1.2.3	EPS	KG,KG	50.00	50.00	0.0	0.0	1	3	1.00	0.0	0.0	1.00	1.00	0.50
102	30.1.1.2.4	THERMAL CONTROL	KG	100.00	0.0	0.0	0.0	1	3	1.00	0.0	0.0	1.00	0.80	0.80
10	30.1.1.2.5	DATA MGMT	KG,KG	25.00	25.00	0.0	0.0	1	3	1.00	0.0	0.0	1.00	1.00	0.80
103	30.1.1.2.6	RMS	DLR	0.0	10.000	0.0		1	2	1.00	0.0				
104	30.1.1.2.7	HPA	DLR	0.0	10.680	0.0		1	1	1.00	0.0				
105	30.1.1.2.9	OCP	DLR	0.0	3.220	0.0		1	1	1.00	0.0				
182	30.1.1.2.11	MMU	DLR	0.0	1.580	0.0		1	1	1.00	0.0				
139	20.1.1.2.1	PALLET	KG	582.00	0.0	0.0	0.0	1	1	1.00	0.0	1.00	1.00	1.00	0.0
139	20.1.1.2.1	PALLET	DLR	0.0	8.870	0.0		1	1	1.00	0.0				
141	20.1.1.2.5	EPS	KG,KG	1140.00	1140.00	0.0	0.0	1	2	1.00	0.0	0.0	1.00	1.00	0.80
142	20.1.1.2.6	SOLAR ARRAY	WATTS	48000.00	0.0	0.0	0.0	1	2	1.00	0.0	0.0	1.00	1.00	0.80
207	80.0	TRANSPORTATION	DLR	0.0	84.100	0.0		2	2	1.00	0.0				

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE FFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED, PROFIT EXCLUDED

EVOLVED CLUSTER LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
1.0	SPACE STATION	375.69	48.31	423.99	964.29	1178.62	85.48	1264.10	0.0	0.0	0.0	1688.09
10.0	HABITAT 3MEN	0.0	0.0	0.0	471.14	471.14	51.30	522.44	0.0	0.0	0.0	522.44
40.0	LAB MODULE	268.74	48.31	317.05	93.54	158.26	9.71	167.96	0.0	0.0	0.0	485.01
40.1	SPACECRAFT SEG	255.36	48.31	303.67	93.54	158.26	9.71	167.96	0.0	0.0	0.0	471.64
40.1.1	HARDWARE	133.32	44.49	177.81	76.14	140.86	9.71	150.57	0.0	0.0	0.0	328.37
40.1.1.1	IACO	20.25	6.86	27.11	11.43	11.43	0.0	11.43	0.0	0.0	0.0	38.54
40.1.1.2	SUBSYSTEMS	113.07	37.63	150.70	64.72	129.43	9.71	139.14	0.0	0.0	0.0	289.84
40.1.1.2.1	STRUCTURE	23.32	19.36	42.69	32.27	64.54	4.84	69.38	0.0	0.0	0.0	112.07
40.1.1.2.2	BERTHING	0.0	0.0	0.0	2.00	4.00	0.30	4.30	0.0	0.0	0.0	4.30
40.1.1.2.3	EPS	7.41	1.91	9.32	3.19	6.37	0.48	6.85	0.0	0.0	0.0	16.18
40.1.1.2.4	ECLS	32.83	2.52	35.35	4.20	8.41	0.63	9.04	0.0	0.0	0.0	44.39
40.1.1.2.5	THERMAL CONTROL	2.25	7.52	9.77	12.54	25.08	1.88	26.96	0.0	0.0	0.0	36.73
40.1.1.2.6	CONTR & DISPL	8.31	0.36	8.66	0.60	1.19	0.09	1.28	0.0	0.0	0.0	9.95
40.1.1.2.7	DATA MGMT/COMM	28.51	2.28	30.80	3.80	7.61	0.57	8.18	0.0	0.0	0.0	38.97
40.1.1.2.9	CREW ACCOMM	10.44	3.67	14.11	6.11	12.23	0.92	13.15	0.0	0.0	0.0	27.26
40.1.3	SERVICES	59.36	3.82	63.18	17.40	17.40	0.0	17.40	0.0	0.0	0.0	80.58
40.1.3.1	SE&I	27.95	0.0	27.95	9.51	9.51	0.0	9.51	0.0	0.0	0.0	37.46
40.1.3.2	PM	20.94	3.82	24.76	6.37	6.37	0.0	6.37	0.0	0.0	0.0	31.13
40.1.3.3	OTHER	10.47	0.0	10.47	1.52	1.52	0.0	1.52	0.0	0.0	0.0	11.99
40.1.5	GSE	62.68	0.0	62.68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	62.68
40.4	INT&TST SYS LEV	13.38	0.0	13.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.38
30.0	SURROGATE	0.0	0.0	0.0	54.14	85.74	5.44	91.18	0.0	0.0	0.0	91.18
30.1	SPACECRAFT SEG	0.0	0.0	0.0	54.14	85.74	5.44	91.18	0.0	0.0	0.0	91.18
30.1.1	HARDWARE	0.0	0.0	0.0	43.34	74.94	5.44	80.38	0.0	0.0	0.0	80.38
30.1.1.1	IACO	0.0	0.0	0.0	7.06	7.06	0.0	7.06	0.0	0.0	0.0	7.06
30.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	36.28	67.88	5.44	73.32	0.0	0.0	0.0	73.32

****** NOTES ON SPACE MODEL OUTPUT ******

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G&A INCLUDED,PROFIT EXCLUDED

EVOLVED CLUSTER LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
30.1.1.2.1	STRUCTURE	0.0	0.0	0.0	4.38	13.13	0.66	13.79	0.0	0.0	0.0	13.79
30.1.1.2.3	EPS	0.0	0.0	0.0	1.60	4.81	0.24	5.05	0.0	0.0	0.0	5.05
30.1.1.2.4	THERMAL CONTROL	0.0	0.0	0.0	2.81	8.42	0.42	8.84	0.0	0.0	0.0	8.84
30.1.1.2.5	DATA MGMT	0.0	0.0	0.0	2.01	6.04	0.30	6.34	0.0	0.0	0.0	6.34
30.1.1.2.6	RMS	0.0	0.0	0.0	10.00	20.00	1.50	21.50	0.0	0.0	0.0	21.50
30.1.1.2.7	HPA	0.0	0.0	0.0	10.68	10.68	1.60	12.28	0.0	0.0	0.0	12.28
30.1.1.2.9	OCP	0.0	0.0	0.0	3.22	3.22	0.48	3.70	0.0	0.0	0.0	3.70
30.1.1.2.11	MMU	0.0	0.0	0.0	1.58	1.58	0.24	1.82	0.0	0.0	0.0	1.82
30.1.3	SERVICES	0.0	0.0	0.0	10.80	10.80	0.0	10.80	0.0	0.0	0.0	10.80
30.1.3.1	SE&I	0.0	0.0	0.0	5.87	5.87	0.0	5.87	0.0	0.0	0.0	5.87
30.1.3.2	PM	0.0	0.0	0.0	4.06	4.06	0.0	4.06	0.0	0.0	0.0	4.06
30.1.3.3	OTHER	0.0	0.0	0.0	0.87	0.87	0.0	0.87	0.0	0.0	0.0	0.87
20.0	EXT. SUBSYSTEMS	106.94	0.0	106.94	177.26	295.28	19.03	314.31	0.0	0.0	0.0	421.25
20.1	SPACECRAFT SEG	85.91	0.0	85.91	177.26	295.28	19.03	314.31	0.0	0.0	0.0	400.22
20.1.1	HARDWARE	24.95	0.0	24.95	146.90	264.91	19.03	283.94	0.0	0.0	0.0	308.89
20.1.1.1	IACO	24.95	0.0	24.95	20.01	20.01	0.0	20.01	0.0	0.0	0.0	44.96
20.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	126.88	244.90	19.03	263.93	0.0	0.0	0.0	263.93
20.1.1.2.1	PALLET	0.0	0.0	0.0	8.87	8.87	1.33	10.20	0.0	0.0	0.0	10.20
20.1.1.2.5	EPS	0.0	0.0	0.0	18.61	37.23	2.79	40.02	0.0	0.0	0.0	40.02
20.1.1.2.6	SOLAR ARRAY	0.0	0.0	0.0	99.40	198.80	14.91	213 71	0.0	0.0	0.0	213.71
20.1.3	SERVICES	26.52	0.0	26.52	30.37	30.37	0.0	30.37	0.0	0.0	0.0	56.88
20.1.3.1	SE&I	12.09	0.0	12.09	16.67	16.67	0.0	16.67	0.0	0.0	0.0	28.76
20.1.3.2	PM	10.41	0.0	10.41	10.76	10.76	0.0	10.76	0.0	0.0	0.0	21.16
20.1.3.3	OTHER	4.02	0.0	4.02	2.94	2.94	0.0	2.94	0.0	0.0	0.0	6.96
20.1.5	GSE	34.45	0.0	34.45	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.45
20.4	INT&TST SYS LEV	21.03	0.0	21.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.03
80.0	TRANSPORTATION	0.0	0.0	0.0	168.20	168.20	0.0	168.20	0.0	0.0	0.0	168.20
1.1	PROG SPPT	52.60	0.0	52.60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	52.60
1.2	MGMT & INTEG	18.78	0.0	18.78	48.21	48.21	0.0	48.21	0.0	0.0	0.0	67.00
1.3	LAUNCH & LANDING	4.52	0.0	4.52	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.52

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COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

INITIAL T.F.P. INPUTS---- MODE **RUN 314-1**

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMM DDT&E	COMPLEXITY DDT&E	COMPLEXITY TFU	SODEV DDT&E
50	10.0	HABITAT 3MEN	DLR	0.0	235.570	0.0		1	1	1.00	0.0				
100	30.1.1.2.1	STRUCTURE	KG	964.00	0.0	0.0	0.0	1	4	1.00	0.0	0.0	0.70	0.70	0.70
174	30.1.1.2.3	EPS	KG,KG	50.00	50.00	0.0	0.0	1	4	1.00	0.0	0.0	1.00	1.00	0.50
10	30.1.1.2.5	DATA MGMT	KG,KG	25.00	25.00	0.0	0.0	1	4	1.00	0.0	0.0	1.00	1.00	0.80
120	70.1.1.2.1	STRUCTURE	KG	50.00	0.0	0.0	0.0	1	4	1.00	0.0	0.0	0.70	0.70	0.70
120	70.1.1.2.1	STRUCTURE	DLR	0.0	6.000	0.0		1	4	1.00	0.0				
121	70.1.1.2.2	IPS	KG	2320.00	0.0	0.0	0.0	1	4	1.00	0.0	1.00	1.00	1.00	0.0
121	70.1.1.2.2	IPS	DLR	0.0	13.350	0.0		1	4	1.00	0.0				
139	20.1.1.2.1	PALLET	KG	582.00	0.0	0.0	0.0	1	1	1.00	0.0	1.00	1.00	1.00	0.0
139	20.1.1.2.1	PALLET	DLR	0.0	8.870	0.0		1	1	1.00	0.0				
205	20.1.1.2.2	TOWER	KG	500.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	0.90	1.00
206	20.1.1.2.3	GIMBAL	KG	1000.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	0.90	1.00
141	20.1.1.2.5	EPS	KG,KG	820.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
142	20.1.1.2.6	SOLAR ARRAY	WATTS	36000.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
175	20.1.1.2.7	RCS	KG,KG	340.00	340.00	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
143	20.1.1.2.8	GN&C	KG,KG	380.00	380.00	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	1.00
207	80.0	TRANSPORTATION	DLR	0.0	126.150	0.0		1	1	1.00	0.0				

11/3

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL FOR QUANTITY SPECIFIED (SEE FFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED,PROFIT EXCLUDED

INITIAL T.F.P. LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
1.0	SPACE STATION	57.23	0.0	57.23	573.63	655.66	46.44	702.10	0.0	0.0	0.0	759.33
10.0	HABITAT 3MEN	0.0	0.0	0.0	235.57	235.57	25.65	261.22	0.0	0.0	0.0	261.22
30.0	SURROGATE	0.0	0.0	0.0	13.14	37.12	1.20	38.32	0.0	0.0	0.0	38.32
30.1	SPACECRAFT SEG	0.0	0.0	0.0	13.14	37.12	1.20	38.32	0.0	0.0	0.0	38.32
30.1.1	HARDWARE	0.0	0.0	0.0	10.00	33.99	1.20	35.19	0.0	0.0	0.0	35.19
30.1.1.1	IACO	0.0	0.0	0.0	2.01	2.01	0.0	2.01	0.0	0.0	0.0	2.01
30.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	8.00	31.98	1.20	33.18	0.0	0.0	0.0	33.18
30.1.1.2.1	STRUCTURE	0.0	0.0	0.0	4.38	17.51	0.66	18.17	0.0	0.0	0.0	18.17
30.1.1.2.3	EPS	0.0	0.0	0.0	1.60	6.42	0.24	6.66	0.0	0.0	0.0	6.66
30.1.1.2.5	DATA MGMT	0.0	0.0	0.0	2.01	8.06	0.30	8.36	0.0	0.0	0.0	8.36
30.1.3	SERVICES	0.0	0.0	0.0	3.14	3.14	0.0	3.14	0.0	0.0	0.0	3.14
30.1.3.1	SE&I	0.0	0.0	0.0	1.68	1.68	0.0	1.68	0.0	0.0	0.0	1.68
30.1.3.2	PM	0.0	0.0	0.0	1.26	1.26	0.0	1.26	0.0	0.0	0.0	1.26
30.1.3.3	OTHER	0.0	0.0	0.0	0.20	0.20	0.0	0.20	0.0	0.0	0.0	0.20
70.0	OBSERV. MODULE	57.23	0.0	57.23	29.99	88.04	2.90	90.94	0.0	0.0	0.0	148.17
70.1	SPACECRAFT SEG	51.29	0.0	51.29	29.99	88.04	2.90	90.94	0.0	0.0	0.0	142.23
70.1.1	HARDWARE	13.93	0.0	13.93	23.54	81.59	2.90	84.49	0.0	0.0	0.0	98.42
70.1.1.1	IACO	13.93	0.0	13.93	4.19	4.19	0.0	4.19	0.0	0.0	0.0	18.12
70.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	19.35	77.40	2.90	80.30	0.0	0.0	0.0	80.30
70.1.1.2.1	STRUCTURE	0.0	0.0	0.0	6.00	24.00	0.90	24.90	0.0	0.0	0.0	24.90
70.1.1.2.2	IPS	0.0	0.0	0.0	13.35	53.40	2.00	55.40	0.0	0.0	0.0	55.40
70.1.3	SERVICES	15.01	0.0	15.01	6.45	6.45	0.0	6.45	0.0	0.0	0.0	21.46
70.1.3.1	SE&I	6.41	0.0	6.41	3.48	3.48	0.0	3.48	0.0	0.0	0.0	9.89
70.1.3.2	PM	6.50	0.0	6.50	2.50	2.50	0.0	2.50	0.0	0.0	0.0	8.99
70.1.3.3	OTHER	2.11	0.0	2.11	0.47	0.47	0.0	0.47	0.0	0.0	0.0	2.58
70.1.5	GSE	22.35	0.0	22.35	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.35
70.4	INT&TST SYS LEV	5.94	0.0	5.94	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.94
20.0	EXT. SUBSYSTEMS	0.0	0.0	0.0	168.79	168.79	16.68	185.47	0.0	0.0	0.0	185.47
20.1	SPACECRAFT SEG	0.0	0.0	0.0	168.79	168.79	16.68	185.47	0.0	0.0	0.0	185.47
20.1.1	HARDWARE	0.0	0.0	0.0	139.69	139.69	16.68	156.37	0.0	0.0	0.0	156.37
20.1.1.1	IACO	0.0	0.0	0.0	19.17	19.17	0.0	19.17	0.0	0.0	0.0	19.17
20.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	120.52	120.52	16.68	137.20	0.0	0.0	0.0	137.20
20.1.1.2.1	PALLET	0.0	0.0	0.0	8.87	8.87	1.33	10.20	0.0	0.0	0.0	10.20
20.1.1.2.2	TOWER	0.0	0.0	0.0	3.50	3.50	0.0	3.50	0.0	0.0	0.0	3.50
20.1.1.2.3	GIMBAL	0.0	0.0	0.0	5.78	5.78	0.0	5.78	0.0	0.0	0.0	5.78
20.1.1.2.6	SOLAR ARRAY	0.0	0.0	0.0	86.76	86.76	13.01	99.77	0.0	0.0	0.0	99.77
20.1.1.2.7	RCS	0.0	0.0	0.0	4.20	4.20	0.63	4.83	0.0	0.0	0.0	4.83
20.1.1.2.8	GN&C	0.0	0.0	0.0	11.41	11.41	1.71	13.12	0.0	0.0	0.0	13.12
20.1.3	SERVICES	0.0	0.0	0.0	29.10	29.10	0.0	29.10	0.0	0.0	0.0	29.10
20.1.3.1	SE&I	0.0	0.0	0.0	15.97	15.97	0.0	15.97	0.0	0.0	0.0	15.97
20.1.3.2	PM	0.0	0.0	0.0	10.33	10.33	0.0	10.33	0.0	0.0	0.0	10.33
20.1.3.3	OTHER	0.0	0.0	0.0	2.79	2.79	0.0	2.79	0.0	0.0	0.0	2.79
80.0	TRANSPORTATION	0.0	0.0	0.0	126.15	126.15	0.0	126.15	0.0	0.0	0.0	126.15
1.1	PROG SPPT	8.01	0.0	8.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.01
1.2	MGMT & INTEG	2.86	0.0	2.86	28.68	28.68	0.0	28.68	0.0	0.0	0.0	31.54

ORIGINAL PAGE IS
OF POOR QUALITY

***** NOTES ON SPACE MODEL INPUTS *****

THIS TABLE LISTS ONLY THOSE WBS ITEMS WHICH ARE COSTED BY $ THRUPUT AND/OR PARAMETRIC COST DRIVERS
WHEN INPUTS ARE DOLLAR THRUPUTS; COL. 1 IS FOR DDT&E, COL. 2 IS FOR PRODUCTION, COL. 3 IS FOR OPERATIONS
WHEN INPUTS ARE WTS SPECIFIED AS KG,KG; COL. 1 IS FOR NON-REPLICATED WT, COL. 2 IS FOR TOTAL DRY WT.
WHEN INPUTS ARE WTS SPECIFIED AS KG; COL. 1 IS FOR TOTAL DRY WT.
QUANTITY PFU = PER FIRST UNIT, TOT = TOTAL PROD. QTY
COMMONALITY FACTOR 1 = NO COST REDUCTION DUE TO COST SHARING 0 = 100% COST REDUCTION DUE TO COMMONALITY
COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

EVOLVED T.P.P. INPUTS---- MODE **RUN 314-2**

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMN DDT&E	COMPLEXITY DDT&E	TFU	SODEV DDT&E
100	30.1.1.2.1	STRUCTURE	KG	964.00	0.0	0.0	0.0	1	2	1.00	0.0	0.0	0.70	0.70	0.70
174	30.1.1.2.3	EPS	KG,KG	50.00	50.00	0.0	0.0	1	2	1.00	0.0	0.0	1.00	1.00	0.50
10	30.1.1.2.5	DATA MGMT	KG,KG	25.00	25.00	0.0	0.0	1	2	1.00	0.0	0.0	1.00	1.00	0.80
120	70.1.1.2.1	STRUCTURE	KG	50.00	0.0	0.0	0.0	1	3	1.00	0.0	0.0	0.70	0.70	0.70
120	70.1.1.2.1	STRUCTURE	DLR	0.0	6.100	0.0		1	3	1.00	0.0				
121	70.1.1.2.2	IPS	KG	2320.00	0.0	0.0	0.0	1	8	1.00	0.0	1.00	1.00	1.00	0.0
121	70.1.1.2.2	IPS	DLR	0.0	13.350	0.0		1	8	1.00	0.0				
141	20.1.1.2.5	EPS	KG,KG	820.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
142	20.1.1.2.6	SOLAR ARRAY	WATTS	36000.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
207	80.0	TRANSPORTATION	DLR	0.0	84.100	0.0		1	1	1.00	0.0				

ORIGINAL PAGE IS
OF POOR QUALITY

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST-UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE PFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED,PROFIT EXCLUDED

EVOLVED T.P.P. LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
1.0	SPACE STATION	57.32	0.0	57.32	250.87	364.52	17.13	381.65	0.0	0.0	0.0	438.97
30.0	SURROGATE	0.0	0.0	0.0	13.14	21.13	1.20	22.33	0.0	0.0	0.0	22.33
30.1	SPACECRAFT SEG	0.0	0.0	0.0	13.14	21.13	1.20	22.33	0.0	0.0	0.0	22.33
30.1.1	HARDWARE	0.0	0.0	0.0	10.00	18.00	1.20	19.20	0.0	0.0	0.0	19.20
30.1.1.1	IACO	0.0	0.0	0.0	2.01	2.01	0.0	2.01	0.0	0.0	0.0	2.01
30.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	8.00	15.99	1.20	17.19	0.0	0.0	0.0	17.19
30.1.1.2.1	STRUCTURE	0.0	0.0	0.0	4.38	8.75	0.66	9.41	0.0	0.0	0.0	9.41
30.1.1.2.3	EPS	0.0	0.0	0.0	1.60	3.21	0.24	3.45	0.0	0.0	0.0	3.45
30.1.1.2.5	DATA MGMT	0.0	0.0	0.0	2.01	4.03	0.30	4.33	0.0	0.0	0.0	4.33
30.1.3	SERVICES	0.0	0.0	0.0	3.14	3.14	0.0	3.14	0.0	0.0	0.0	3.14
30.1.3.1	SE&I	0.0	0.0	0.0	1.68	1.68	0.0	1.68	0.0	0.0	0.0	1.68
30.1.3.2	PM	0.0	0.0	0.0	1.26	1.26	0.0	1.26	0.0	0.0	0.0	1.26
30.1.3.3	OTHER	0.0	0.0	0.0	0.20	0.20	0.0	0.20	0.0	0.0	0.0	0.20
70.0	OBSERV. MODULE	57.32	0.0	57.32	30.13	135.78	2.92	138.70	0.0	0.0	0.0	196.02
70.1	SPACECRAFT SEG	51.36	0.0	51.36	30.13	135.78	2.92	138.70	0.0	0.0	0.0	190.06
70.1.1	HARDWARE	13.95	0.0	13.95	23.65	129.30	2.92	132.22	0.0	0.0	0.0	146.17
70.1.1.1	IACO	13.95	0.0	13.95	4.20	4.20	0.0	4.20	0.0	0.0	0.0	18.16
70.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	19.45	125.10	2.92	128.02	0.0	0.0	0.0	128.02
70.1.1.2.1	STRUCTURE	0.0	0.0	0.0	6.10	18.30	0.91	19.21	0.0	0.0	0.0	19.21
70.1.1.2.2	IPS	0.0	0.0	0.0	13.35	106.80	2.00	108.80	0.0	0.0	0.0	108.80
70.1.3	SERVICES	15.03	0.0	15.03	6.48	6.48	0.0	6.48	0.0	0.0	0.0	21.51
70.1.3.1	SE&I	6.41	0.0	6.41	3.50	3.50	0.0	3.50	0.0	0.0	0.0	9.91
70.1.3.2	PM	6.50	0.0	6.50	2.51	2.51	0.0	2.51	0.0	0.0	0.0	9.01
70.1.3.3	OTHER	2.11	0.0	2.11	0.47	0.47	0.0	0.47	0.0	0.0	0.0	2.59
70.1.5	GSE	22.37	0.0	22.37	0.0	0.0	0.0	0.0	0.0	0.0	0.0	22.37
70.4	INT&TST SYS LEV	5.96	0.0	5.96	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.96
20.0	EXT. SUBSYSTEMS	0.0	0.0	0.0	123.50	123.50	13.01	136.52	0.0	0.0	0.0	136.52
20.1	SPACECRAFT SEG	0.0	0.0	0.0	123.50	123.50	13.01	136.52	0.0	0.0	0.0	136.52
20.1.1	HARDWARE	0.0	0.0	0.0	101.34	101.34	13.01	114.35	0.0	0.0	0.0	114.35
20.1.1.1	IACO	0.0	0.0	0.0	14.58	14.58	0.0	14.58	0.0	0.0	0.0	14.58
20.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	86.76	86.76	13.01	99.77	0.0	0.0	0.0	99.77
20.1.1.2.6	SOLAR ARRAY	0.0	0.0	0.0	86.76	86.76	13.01	99.77	0.0	0.0	0.0	99.77
20.1.3	SERVICES	0.0	0.0	0.0	22.16	22.16	0.0	22.16	0.0	0.0	0.0	22.16
20.1.3.1	SE&I	0.0	0.0	0.0	12.14	12.14	0.0	12.14	0.0	0.0	0.0	12.14
20.1.3.2	PM	0.0	0.0	0.0	8.00	8.00	0.0	8.00	0.0	0.0	0.0	8.00
20.1.3.3	OTHER	0.0	0.0	0.0	2.03	2.03	0.0	2.03	0.0	0.0	0.0	2.03
80.0	TRANSPORTATION	0.0	0.0	0.0	84.10	84.10	0.0	84.10	0.0	0.0	0.0	84.10
1.1	PROG SPPT	8.03	0.0	8.03	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.03
1.2	MGMT & INTEG	2.87	0.0	2.87	12.54	12.54	0.0	12.54	0.0	0.0	0.0	15.41

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ORIGINAL PAGE IS
OF POOR QUALITY

***** NOTES ON SPACE MODEL INPUTS *****

THIS TABLE LISTS ONLY THOSE WBS ITEMS WHICH ARE COSTED BY $ THRUPUT AND/OR PARAMETRIC COST DRIVERS
WHEN INPUTS ARE DOLLAR THRUPUTS; COL. 1 IS FOR DDT&E, COL. 2 IS FOR PRODUCTION, COL. 3 IS FOR OPERATIONS
WHEN INPUTS ARE WTS SPECIFIED AS KG,KG; COL. 1 IS FOR NON-REPLICATED WT, COL. 2 IS FOR TOTAL DRY WT.
WHEN INPUTS ARE WTS SPECIFIED AS KG; COL. 1 IS FOR TOTAL DRY WT.
QUANTITY PFU = PER FIRST UNIT, TOT = TOTAL PROD. QTY
COMMONALITY FACTOR 1 = NO COST REDUCTION DUE TO COST SHARING 0 = 100% COST REDUCTION DUE TO COMMONALITY
COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

INDUST PLATFORM INPUTS---- MODE **RUN 310-3**

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMN DDT&E	COMPLEXITY DDT&E	TFU	SODEV DDT&E
4	10.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
6	10.1.1.2.1	STRUCTURE	KG	3650.00	0.0	0.0	0.0	1	1	1.00	0.60	0.20	1.00	0.73	0.80
7	10.1.1.2.2	BERTHING	KG	68.00	0.0	0.0	0.0	2	2	1.00	0.0	0.0	1.00	1.00	1.00
7	10.1.1.2.2	BERTHING	DLR	0.0	0.500	0.0		2	2	1.00	0.0				
8	10.1.1.2.3	EPS	KG,KG	30.00	30.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	0.50
11	10.1.1.2.4	ECLS	KG,KG	50.00	50.00	0.0	0.0	1	1	1.00	0.60	0.0	1.00	0.80	0.50
12	10.1.1.2.5	THERMAL CONTROL	KG	1500.00	0.0	0.0	0.0	1	1	1.00	0.60	0.17	1.00	0.80	0.80
166	10.1.1.2.6	CONTR & DISPL	KG	40.00	0.0	0.0	0.0	1	1	1.00	0.60	0.40	1.00	1.00	0.80
14	10.1.1.2.8	DATA MGMT	KG,KG	250.00	250.00	0.0	0.0	1	1	1.00	0.60	0.30	1.00	1.00	0.80
15	10.1.1.2.9	COMMUNICATION	KG,KG	150.00	150.00	0.0	0.0	1	1	1.00	0.60	0.30	1.00	1.00	0.80
16	10.1.1.2.10	GN&C	KG,KG	120.00	120.00	0.0	0.0	1	1	1.00	0.60	0.40	1.00	1.00	0.80
169	10.1.1.2.12	TUNNEL	KG	250.00	0.0	0.0	0.0	1	1	1.00	0.60	0.0	1.00	0.90	0.90
19	10.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
139	20.1.1.2.1	PALLET	KG	582.00	0.0	0.0	0.0	1	1	1.00	0.0	1.00	1.00	1.00	0.0
139	20.1.1.2.1	PALLET	DLR	0.0	8.870	0.0		1	1	1.00	0.0				
206	20.1.1.2.3	GIMBAL	KG	1000.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	0.90	1.00
141	20.1.1.2.5	EPS	KG,KG	1140.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
142	20.1.1.2.6	SOLAR ARRAY	WATTS	48000.00	0.0	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
175	20.1.1.2.7	RCS	KG,KG	340.00	340.00	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	0.80
143	20.1.1.2.8	GN&C	KG,KG	380.00	380.00	0.0	0.0	1	1	1.00	0.0	0.0	1.00	1.00	1.00
207	80.0	TRANSPORTATION	DLR	0.0	64.000	0.0		1	1	1.00	0.0				

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE PFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED,PROFIT EXCLUDED

INDUST PLATFORM LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
1.0	SPACE STATION	345.97	58.40	404.38	356.18	356.18	30.24	386.42	0.0	0.0	0.0	790.80
10.0	HABITAT 3MAN	345.97	58.40	404.38	111.23	111.23	11.65	122.89	0.0	0.0	0.0	527.26
10.1	SPACECRAFT SEG	330.84	58.40	389.25	111.23	111.23	11.65	122.89	0.0	0.0	0.0	512.13
10.1.1	HARDWARE	183.47	54.00	237.47	91.00	91.00	11.65	102.65	0.0	0.0	0.0	340.13
10.1.1.1	IACO	21.43	7.98	29.41	13.31	13.31	0.0	13.31	0.0	0.0	0.0	42.72
10.1.1.2	SUBSYSTEMS	162.04	46.02	208.06	77.69	77.69	11.65	89.35	0.0	0.0	0.0	297.41
10.1.1.2.1	STRUCTURE	23.32	9.68	33.00	16.14	16.14	2.42	18.56	0.0	0.0	0.0	51.56
10.1.1.2.2	BERTHING	0.0	0.0	0.0	1.00	1.00	0.15	1.15	0.0	0.0	0.0	1.15
10.1.1.2.3	EPS	3.30	0.64	3.94	1.07	1.07	0.16	1.24	0.0	0.0	0.0	5.18
10.1.1.2.4	ECLS	0.0	4.03	4.03	6.72	6.72	1.01	7.73	0.0	0.0	0.0	11.77
10.1.1.2.5	THERMAL CONTROL	1.74	7.52	9.26	12.54	12.54	1.88	14.42	0.0	0.0	0.0	23.68
10.1.1.2.6	CONTR & DISPL	3.32	0.36	3.68	0.60	0.60	0.09	0.69	0.0	0.0	0.0	4.37
10.1.1.2.8	DATA MGMT	72.40	9.98	82.39	16.64	16.64	2.50	19.13	0.0	0.0	0.0	101.52
10.1.1.2.9	COMMUNICATION	53.87	6.25	60.11	10.41	10.41	1.56	11.98	0.0	0.0	0.0	72.09
10.1.1.2.10	GN&C	4.10	3.87	7.97	6.46	6.46	0.97	7.43	0.0	0.0	0.0	15.39
10.1.1.2.12	TUNNEL	0.0	3.67	3.67	6.11	6.11	0.92	7.03	0.0	0.0	0.0	10.70
10.1.3	SERVICES	74.08	4.40	78.49	20.23	20.23	0.0	20.23	0.0	0.0	0.0	98.72
10.1.3.1	SE&I	35.14	0.0	35.14	11.07	11.07	0.0	11.07	0.0	0.0	0.0	46.21
10.1.3.2	PM	25.35	4.40	29.75	7.34	7.34	0.0	7.34	0.0	0.0	0.0	37.09
10.1.3.3	OTHER	13.59	0.0	13.59	1.82	1.82	0.0	1.82	0.0	0.0	0.0	15.41
10.1.5	GSE	73.29	0.0	73.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	73.29
10.4	INT&TST SYS LEV	15.13	0.0	15.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.13
20.0	EXT. SUBSYSTEMS	0.0	0.0	0.0	180.95	180.95	18.58	199.53	0.0	0.0	0.0	199.53
20.1	SPACECRAFT SEG	0.0	0.0	0.0	180.95	180.95	18.58	199.53	0.0	0.0	0.0	199.53
20.1.1	HARDWARE	0.0	0.0	0.0	150.03	150.03	18.58	168.62	0.0	0.0	0.0	168.62
20.1.1.1	IACO	0.0	0.0	0.0	20.37	20.37	0.0	20.37	0.0	0.0	0.0	20.37
20.1.1.2	SUBSYSTEMS	0.0	0.0	0.0	129.66	129.66	18.58	148.24	0.0	0.0	0.0	148.24
20.1.1.2.1	PALLET	0.0	0.0	0.0	8.87	8.87	1.33	10.20	0.0	0.0	0.0	10.20
20.1.1.2.3	GIMBAL	0.0	0.0	0.0	5.78	5.78	0.0	5.78	0.0	0.0	0.0	5.78
20.1.1.2.6	SOLAR ARRAY	0.0	0.0	0.0	99.40	99.40	14.91	114.31	0.0	0.0	0.0	114.31
20.1.1.2.7	RCS	0.0	0.0	0.0	4.20	4.20	0.63	4.83	0.0	0.0	0.0	4.83
20.1.1.2.8	GN&C	0.0	0.0	0.0	11.41	11.41	1.71	13.12	0.0	0.0	0.0	13.12
20.1.3	SERVICES	0.0	0.0	0.0	30.92	30.92	0.0	30.92	0.0	0.0	0.0	30.92
20.1.3.1	SE&I	0.0	0.0	0.0	16.98	16.98	0.0	16.98	0.0	0.0	0.0	16.98
20.1.3.2	PM	0.0	0.0	0.0	10.94	10.94	0.0	10.94	0.0	0.0	0.0	10.94
20.1.3.3	OTHER	0.0	0.0	0.0	3.00	3.00	0.0	3.00	0.0	0.0	0.0	3.00
80.0	TRANSPORTATION	0.0	0.0	0.0	64.00	64.00	0.0	64.00	0.0	0.0	0.0	64.00
1.1	PROG SPPT	48.44	0.0	48.44	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.44
1.2	MGMT & INTEG	17.30	0.0	17.30	17.81	17.81	0.0	17.81	0.0	0.0	0.0	35.11
1.3	LAUNCH & LANDING	6.48	0.0	6.48	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.48

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***** NOTES ON SPACE MODEL INPUTS *****

THIS TABLE LISTS ONLY THOSE WBS ITEMS WHICH ARE COSTED BY $ THRUPUT AND/OR PARAMETRIC COST DRIVERS
WHEN INPUTS ARE DOLLAR THRUPUTS; COL. 1 IS FOR DDT&E, COL. 2 IS FOR PRODUCTION, COL. 3 IS FOR OPERATIONS
WHEN INPUTS ARE WTS SPECIFIED AS KG,KG; COL. 1 IS FOR NON-REPLICATED WT, COL. 2 IS FOR TOTAL DRY WT.
WHEN INPUTS ARE WTS SPECIFIED AS KG; COL. 1 IS FOR TOTAL DRY WT.
QUANTITY PFU = PER FIRST UNIT, TOT = TOTAL PROD. QTY
COMMONALITY FACTOR 1 = NO COST REDUCTION DUE TO COST SHARING 0 = 100% COST REDUCTION DUE TO COMMONALITY
COMPLEXITY FACTOR 1 = SAME COMPLEXITY AS IN CER DATA BASE
SODEV (STATE OF DEVELOPMENT) FACTOR 1 = SAME SODEV AS IN CER DATA BASE

OTV STORABLE INPUTS---- MODE RUN 317-1

ITEM NO	WBS	COST ELEMENT	COST DRIVERS	INPUT1	INPUT2	INPUT3	INPUT4	QUANTITY PFU	TOT	PCT LRN	GRD TST	COMN DDT&E	COMPLEXITY DDT&E	TFU	SODEV DDT&E
137	60.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
139	60.1.1.2.1	STRUCTURE	KG	183.00	183.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	1.00
141	60.1.1.2.3	EPS	KG,KG	204.00	204.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	1.00
175	60.1.1.2.5	AVIONICS	KG,KG	181.00	181.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	1.00
143	60.1.1.2.6	GN&C	KG,KG	86.00	86.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	1.00
145	60.1.2	PROPULSION	DLR	17.300	2.230	0.0		1	1	1.00	0.60				
144	60.1.3.2	PM	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
188	90.1.1.1	IACO	DLR	0.0	0.0	0.0		1	1	1.00	0.60				
190	90.1.1.2.1	STRUCTURE	KG	515.00	515.00	0.0	0.0	1	1	1.00	0.60	1.00	1.00	1.00	1.00
195	90.1.2	PROPULSION	DLR	6.700	0.650	0.0		1	1	1.00	0.60				

**** NOTES ON SPACE MODEL OUTPUT ****

FIRST UNIT COST IS TOTAL PER QUANTITY SPECIFIED (SEE PFU QUANTITY INPUT COLUMN)
PRODUCTION COST IS TOTAL FOR THE PRODUCTION QUANTITY SPECIFIED (SEE TOTAL QUANTITY INPUT COLUMN)
G&A INCLUDED, PROFIT EXCLUDED

OTV STORABLE LCC OUTPUT BY PROGRAM PHASE (MILLIONS OF 1984 CONSTANT DOLLARS)

		DDT&E			PRODUCTION				OPERATIONS			
WBS	COST ELEMENT	ENG DES AND DEV	GRD TEST HDWR	TOTAL	FIRST UNIT	VEHICLE PROD	INITIAL SPARES	TOTAL	OPER	OPER SPARES	TOTAL	TOTAL
1.0	SPACE STATION	645.02	33.88	678.90	66.19	66.19	6.53	72.72	0.0	0.0	0.0	751.62
60.0	PROPULSION MOD	403.81	26.51	430.32	50.24	50.24	4.79	55.03	0.0	0.0	0.0	485.35
60.1	SPACECRAFT SEG	320.58	26.51	347.09	50.24	50.24	4.79	55.03	0.0	0.0	0.0	402.12
60.1.1	HARDWARE	143.21	22.97	166.18	38.28	38.28	4.79	43.07	0.0	0.0	0.0	209.25
60.1.1.1	IACO	47.03	3.81	50.84	6.35	6.35	0.0	6.35	0.0	0.0	0.0	57.19
60.1.1.2	SUBSYSTEMS	96.18	19.16	115.34	31.93	31.93	4.79	36.72	0.0	0.0	0.0	152.06
60.1.1.2.1	STRUCTURE	33.53	3.55	37.08	5.92	5.92	0.89	6.61	0.0	0.0	0.0	43.90
60.1.1.2.3	EPS	20.21	2.90	23.11	4.83	4.83	0.72	5.55	0.0	0.0	0.0	28.66
60.1.1.2.5	AVIONICS	30.86	9.42	40.29	15.70	15.70	2.36	18.06	0.0	0.0	0.0	58.34
60.1.1.2.6	GN&C	11.57	3.29	14.86	5.48	5.48	0.82	6.30	0.0	0.0	0.0	21.16
60.1.2	PROPULSION	17.30	1.34	18.64	2.23	2.23	0.0	2.23	0.0	0.0	0.0	20.87
60.1.3	SERVICES	81.65	2.21	83.85	9.72	9.72	0.0	9.72	0.0	0.0	0.0	93.58
60.1.3.1	SE&I	38.84	0.0	38.84	5.28	5.28	0.0	5.28	0.0	0.0	0.0	44.13
60.1.3.2	PM	27.56	2.21	29.77	3.68	3.68	0.0	3.68	0.0	0.0	0.0	33.45
60.1.3.3	OTHER	15.24	0.0	15.24	0.77	0.77	0.0	0.77	0.0	0.0	0.0	16.01
60.1.5	GSE	78.42	0.0	78.42	0.0	0.0	0.0	0.0	0.0	0.0	0.0	78.42
60.4	INT&TST SYS LEV	83.23	0.0	83.23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.23
90.0	TANK	241.22	7.36	248.58	15.95	15.95	1.74	17.69	0.0	0.0	0.0	266.28
90.1	SPACECRAFT SEG	204.79	7.36	212.15	15.95	15.95	1.74	17.69	0.0	0.0	0.0	229.85
90.1.1	HARDWARE	87.86	6.97	94.83	11.62	11.62	1.74	13.36	0.0	0.0	0.0	108.20
90.1.1.1	IACO	32.13	1.37	33.50	2.28	2.28	0.3[illegible]	2.63	0.0	0.0	0.0	36.13
90.1.1.2	SUBSYSTEMS	55.73	5.60	61.33	9.34	9.34	1.40	10.74	0.0	0.0	0.0	72.07
90.1.1.2.1	STRUCTURE	55.73	5.60	61.33	9.34	9.34	1.40	10.74	0.0	0.0	0.0	72.07
90.1.2	PROPULSION	6.70	0.39	7.09	0.65	0.65	0.0	0.65	0.0	0.0	0.0	7.74
90.1.3	SERVICES	52.68	0.0	52.68	3.68	3.68	0.0	3.68	0.0	0.0	0.0	56.36
90.1.3.1	SE&I	24.70	0.0	24.70	2.03	2.03	0.0	2.03	0.0	0.0	0.0	26.73
90.1.3.2	PM	18.89	0.0	18.89	1.42	1.42	0.0	1.42	0.0	0.0	0.0	20.31
90.1.3.3	OTHER	9.09	0.0	9.09	0.23	0.23	0.0	0.23	0.0	0.0	0.0	9.32
90.1.5	GSE	57.54	0.0	57.54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.54
90.4	INT&TST SYS LEV	36.43	0.0	36.43	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.43
1.1	PROG SPPT	90.30	0.0	90.30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	90.30
1.2	MGMT & INTEG	32.25	0.0	32.25	3.31	3.31	0.0	3.31	0.0	0.0	0.0	35.56
1.3	LAUNCH & LANDING	6.08	0.0	6.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.08

APPENDIX B

COST AND SCHEDULE DATA FOR ON-BOARD DATA SYSTEM HARDWARE AND SOFTWARE

B.1 INTRODUCTION

Relative order of magnitude (ROM) costs for hardware and software elements of the Space Station data systems are presented in this Appendix. Included in the hardware costs is the Data Management System (DMS) and the Internal Communication System (ICS).

All cost data has been generated parametrically and expressed in 1984 dollars. Specific cost values were obtained by utilization of appropriate PRICE cost models for hardware and software. Input data has been synthesized based upon assumptions of appropriate parameters. These assumptions reflect experience with generic designs on other programs. Preliminary runs have been made, the data reviewed, and input factors iterated where appropriate, to produce the information contained here. A start date of April, 1986 was assumed.

B.2 COST DATA

B.2.1 HARDWARE COSTS

The two elements which comprise the on-board data system are the Data Management System (DMS) and the Internal Communication System (ICS). Figures 1a and 1b provide the basic information from which the parametric costs were derived. In Fig. 2a and 2b, specific input data for the PRICE hardware model are shown. The data are obtained from Fig. 1a and 1b for the DMS, and ICS respectively, and other factors which are specified on the basis of engineering estimates and simple algorithms. Prices for the DMS and ICS were developed and the resulting data is summarized in Fig. 3. The prices are in terms of 1984 dollars and are plotted against the overall percentage of new design for the two systems.

Fig. 1a

PRELIMINARY ESTIMATE OF SPACE STATION ON-BOARD DATA MANAGEMENT SYSTEM PHYSICAL CHARACTERISTICS

COMPONENT	QUAN	UNIT WT	TOTAL WT (#)	UNIT POWER	TOTAL PWR (WATTS)	UNIT VOL	TOTAL VOL (FT^3)
VIDEO DISK	6	30	180	50	300	.75	4.5
KCRT	9	35	315	51	459	1.7	15.3
MAGNETIC DISKS	5	140	700	300	1500	3	15
COMPUTING NODES (1)	76	.332	25.2	.332	25	.01	.76
PERIPHERAL INTERFACES (2)	200	.33	66.6	.33	60.6	.01	2.0
TOTAL:			1286.8		2350		37.6

(1) CONSISTS OF DATA BUS INTERFACE UNIT, SUBSYSTEM PROCESSOR AND NETWORK PROCESSOR

(2) CONSISTS OF DATA BUS INTERFACE UNIT, RIU'S AND PERIPHERAL INTERFACE DEVICES

Fig. 1b

SPACE STATION ESTIMATED PHYSICAL
CHARACTERISTICS - INTERNAL COMMUNICATION SUBSYSTEM

COMPONENT	QUANTITY	UNIT WT. LBS.	TOTAL WT. LBS.	UNIT PWR WATTS	TOT. PWR WATTS	UNIT VOL. FT^3	TOT. VOL. FT
COMMUNICATION I/F UNIT	33	25	825	25	825	1.5	49.5
AUDIO/VIDEO UNIT	11	5	55	10	110	.15	1.65
TV MONITOR	16	22	352	40	640	.5	8
WIDE SCREEN TV MONITOR	1	50	50	200	200	7	7
TV REMOTE CONTROL	21	27	567	43	1343	1.6	33.6
HAND HELD CAMERA WITH MONITOR	4	21.7	86.8	62	248	.4	1.6
ENTERTAINMENT UNIT	4	25	100	75	300	3	12
TLM MUX	11	3	33	5	55	.1	1.1
VIDEO RECORDER	16	15	240	40	640	.3	4.8
MICROPROCESSOR	11	.332	3.6	.332	3.6	.01	.11
INTERCOM	10	.5	5	5	50	.02	.2
ALARM UNIT	11	1	11	10	110	.10	1.1
REMOTE INTERFARE UNIT	44	.5	22	4	220	.02	.88
TOTAL			2430.4		4878.6		125.3

Fig. 2a

PRICE Worksheet **Basic Modes**

Sheet 1 of 1

**PRICE 84 (This must be used only as the first line of the file.)

Title: ON-BOARD DATA MANAGEMENT

Date: 2/24/83

General A	Production Quantity QTY	Prototypes PROTOS	Weight (lbs) WT	Volume (ft³) VOL	MODE	
		2	1286.8	37.6	1	
General B	Quantity/Next Higher Assembly QTYNHA	NHA Integration Factors Electronic INTEGE	NHA Integration Factors Structural INTEGS	Specification Level PLTFM	Year of Economics YRECON	Year/Type of Technology YRTECH
	1	.5	.5	2.5	1984	1982
Mechanical/ Structural	Structure Weight WS	Manufacturing Complexity MCPLXS	New Structure NEWST	Design Repeat DESRPS	Equipment Classification MECID	Mechanical Reliability MREL
	896.8	10.379	0.3	0.84	0	0
Electronics	Electronics Weight/ft³ WECF	Manufacturing Complexity MCPLXE	New Electronics NEWEL	Design Repeat DESRPE	Equipment Classification CMPID	Electronic Reliability EREL
	43.4	9.719	0.3	0.84	0	0
Development	Development Start DSTART	1st Prototype Complete DFPRO	Development Complete DLPRO	Engineering Complexity ECMPLX	Tooling & Test Equip. DTLGTS	Prototype Activity PROSUP
	1/84	12/87	12/87	1	.000001	1
Production	Production Start PSTART	First Article Delivery PFAD	Production Complete PEND	Cost-Process Factor CPF	Tooling & Test Equip. PTLGTS	Rate/Month Tooling RATOOL
Additional Data (Mode 10)	Electronic Volume Fraction USEVOL	Structural Weight/ft³ WSCF	Target Cost TARCST			

Notes: 50% ANALOG/50% DIGITAL

COMPOSITION: 20% DISC, 20% I.C.; 20% HYBRID, 20% LSI, 20% VLSI

RUN NEW DESIGN FROM 30% TO 80%

BASIC MODES
1 E/M ITEM
2 MECHANICAL IT
6 MODIFIED ITEM
10 DESIGN TO COST

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Fig. 2b

PRICE Input Data Worksheet

Basic Modes

File name: SSIC
Sheet 1 of 1

**PRICE 84 (This must be used only as the first line of the file.)

Title: INTERNAL COMMUNICATIONS

Date: 2/24/83

General A	Production Quantity QTY 0	Prototypes PROTOS 1	Weight (lbs) WT 2430.4	Volume (ft^3) VOL 125.3	MODE 1	
General B	Quantity/Next Higher Assembly QTYNHA 1	NHA Integration Factors Electronic INTEGE .5	Structural INTEGS .5	Specification Level PLTFM 2.5	Year of Economics YRECON 1984	Year/Type of Technology YRTECH 1982
Mechanical/ Structural	Structure Weight WS 1682.9	Manufacturing Complexity MCPLXS 9.852	New Structure NEWST .3	Design Repeat DESRPS .903	Equipment Classification MECID 0	Mechanical Reliability MREL 0
Electronics	Electronics Weight/ft^3 WECF 43.4	Manufacturing Complexity MCPLXE 9.719	New Electronics NEWEL .3	Design Repeat DESRPE .903	Equipment Classification CMPID 0	Electronic Reliability EREL 0
Development	Development Start DSTART 1/84	1st Prototype Complete DFPRO 12/87	Development Complete DLPRO 12/87	Engineering Complexity ECMPLX 1	Tooling & Test Equip. DTLGTS .000001	Prototype Activity PROSUP 1
Production	Production Start PSTART	First Article Delivery PFAD	Production Complete PEND	Cost-Process Factor CPF	Tooling & Test Equip. PTLGTS	Rate/Month Tooling RATOOL
Additional Data (Mode 10)	Electronic Volume Fraction USEVOL	Structural Weight/ft^3 WSCF	Target Cost TARCST			

Notes: 50% ANALOG/50% DIGITAL

COMPOSITION: 20% DISC, 20% I.C., 20% HYBRID, 20% LSI, 20% VLSI

RUN NEW DESIGN FROM 30% TO 80%

BASIC MODES
1 E/M ITEM
2 MECHANICAL ITE
8 MODIFIED ITEM
10 DESIGN [illegible]

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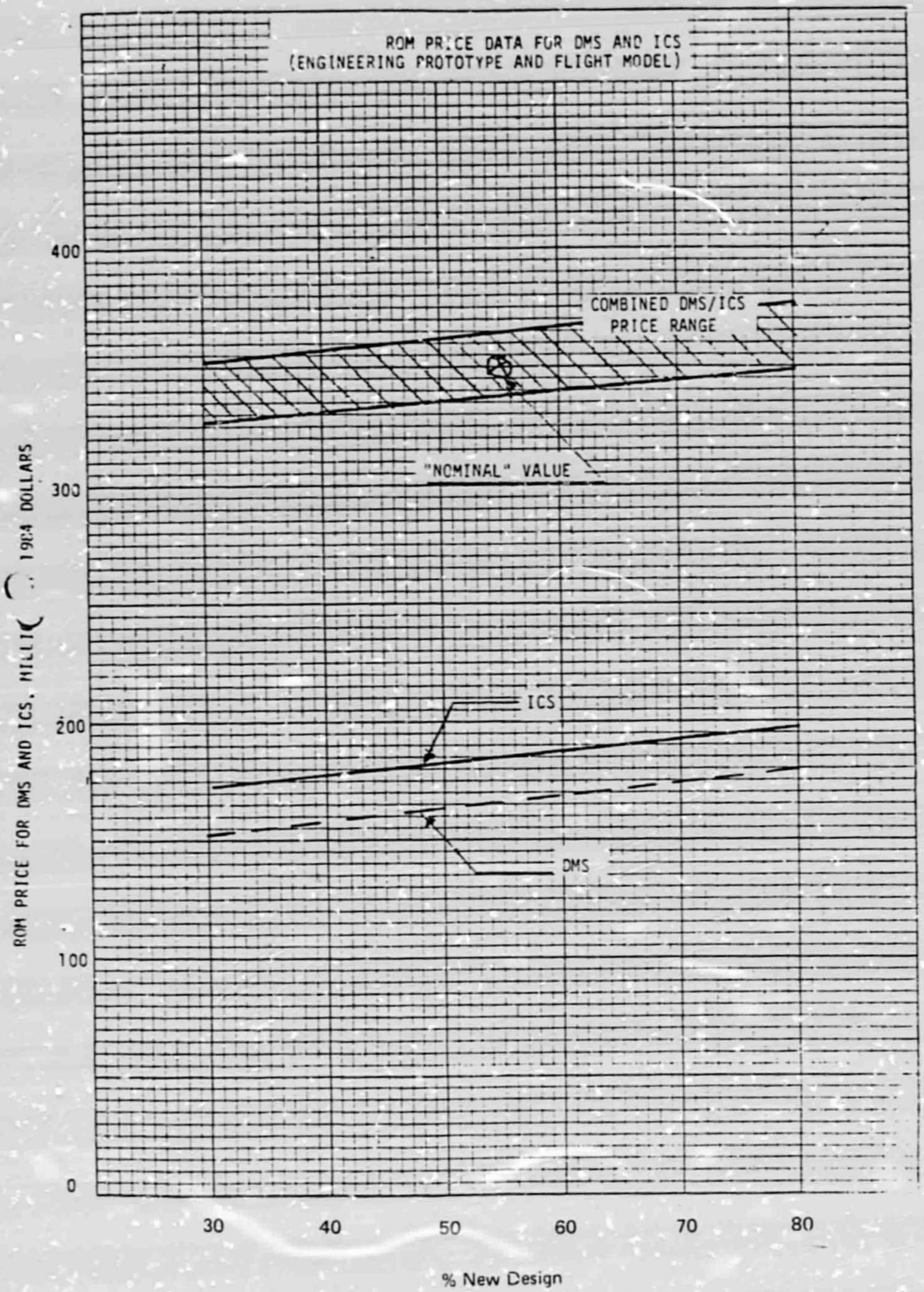
Fig. 3



Current preliminary estimates for the percentage of new design range from 30 to 80 percent. Further refinement of these values would require a more detailed design definition than the scope of this program permits. The costs given here include the production of an engineering prototype and a flight system for the DMS and ICS. A sample data sheet for the ICS is shown in Fig. 3. It provides a cost breakdown as a function of percent new design. Costs are also segregated into 6 categories, e.g., drafting, design, etc., and total cost. Using the mid-point of the price range data, a nominal cost of $350M results for the DMS/ICS hardware.

B.2.2 SOFTWARE COSTS

Costs for on-board space station software were calculated based upon a breakdown of the functions which the software is to perform. The software was apportioned into seven major modules as shown in Fig. 4. The number of instructions for each of the modules was estimated based upon experience and engineering judgement.

The PRICE software model was utilized to develop the cost data. The model also yields schedule estimates. The summary data for the software price and estimated completion dates (based upon an April 1986 start) is shown in Fig. 5. The ROM software price is $125M dollars.

B.2.3 COMBINED HARDWARE/SOFTWARE ROM PRICE

Based upon the information presented above, the ROM price for DMS and IMS hardware and on-board software is as shown:

	Cost in Millions of 1984 $
Hardware	$350M
Software	$125M
Total ROM Price	$475M

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Fig. 4

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NEW OR OLD? O SSICS.LST
*VERIFY OFF
*T F-L,
FILE SEQUENCED
VERIFY ON
*T F-L,NEW DESIGN                       PRICE DATA FOR INTERNAL
*T F-L.NEW DESIGN                        COMMUNICATION SYSTEM

                                         FRACTION NEW DESIGN
00430      NEW DESIGN     0.300    0.300      ELECT VOL FRACTION     .141*
0960       NEW DESIGN     0.400    0.400      ELECT VOL FRACTION     .141*
1490       NEW DESIGN     0.500    0.500      ELECT VOL FRACTION     .141*
2020       NEW DESIGN     0.600    0.600      ELECT VOL FRACTION     .141*
2550       NEW DESIGN     0.700    0.700      ELECT VOL FRACTION     .141*
3090       NEW DESIGN     0.800    0.800      ELECT VOL FRACTION     .141*
T F-L.DRAFTING
00240       DRAFTING        2115.      -      2115.
0770        DRAFTING        2820.      -      2820.
01300       DRAFTING        3525.      -      3525.
01830       DRAFTING        4231.      -      4231.
02360       DRAFTING        4936.      -      4936.
02900       DRAFTING        5641.      -      5641.
*T F-L.DESIGN
00250       DESIGN          7562.      -      7562.         COST IN $K (1984)
0780        DESIGN         10083.      -     10083.
01310       DESIGN         12604.      -     12604.
01840       DESIGN         15125.      -     15125.
02370       DESIGN         17645.      -     17645.
02910       DESIGN         20166.      -     20166.
*T F-L.SYSTEMS
00260       SYSTEMS         1411.      -      1411.
[illegible]90  SYSTEMS      1882.      -      1882.
[illegible]20  SYSTEMS      2352.      -      2352.
[illegible]50  SYSTEMS      2823.      -      2823.
02380       SYSTEMS         3293.      -      3293.
02920       SYSTEMS         3764.      -      3764.
*T F-L.PROJECT MGMT
00270       PROJECT MGMT      11383.      -      11383.
0800        PROJECT MGMT      11811.      -      11811.
01330       PROJECT MGMT      12239.      -      12239.
1860        PROJECT MGMT      12667.      -      12667.
02390       PROJECT MGMT      13095.      -      13095.
2930        PROJECT MGMT      13523.      -      13523.
*T F-L.DATA
00280       DATA            3011.      -      3011.
00810       DATA            3180.      -      3180.
01340       DATA            3349.      -      3349.
01870       DATA            3517.      -      3517.
02400       DATA            3686.      -      3686.
02940       DATA            3855.      -      3855.
*T F-L.PROTOTYPE
00330       PROTOTYPE         132330.      -      132330.
0860        PROTOTYPE         132330.      -      132330.
01390       PROTOTYPE         132330.      -      132330.
1920        PROTOTYPE         132330.      -      132330.
02450       PROTOTYPE         132330.      -      132330.
2990        PROTOTYPE         132330.      -      132330.
[illegible] F-L.TOTAL COST                             COST                PRICE
[illegible]0        TOTAL COST     157813.      -      157813.     -     173,600
0[illegible]0       TOTAL COST     162106.      -      162106.     -     178,300
01430       TOTAL COST     166399.      -      166399.     -     183,000
1960        TOTAL COST     170693.      -      170693.     -     187,762
02490       TOTAL COST     174986.      -      174986.     -     192,485
3030        TOTAL COST     179279.      -      179279.     -     [illegible]
```

Fig. 5

ESTIMATE OF SOFTWARE
INSTRUCTION REQUIREMENTS

SUBSYSTEM	NUMBER OF INSTRUCTIONS, THOUSANDS
DMS APPLICATION	300
SUBSYSTEM CONTROL	25
UTILITIES	175
OPERATING SYSTEM	75
DATA BASE MANAGEMENT	75
DMS NETWORK CONTROL	40
DMS OPERATOR INTERFACE	150
TOTALS:	840

Fig. 6

SUMMARY SOFTWARE DATA

SUBSYSTEM	NUMBER OF INSTRUCTIONS THOUSANDS	COMPLEXITY FACTOR	PRICE IN 1984 \$, THOUSANDS	COMPLETION DATE
DMS APPLICATIONS	300	1.4	60,100	OCT 1991
SUBSYSTEM CONTROL	25	1.2	4,600	DEC 1988
UTILITIES	175	1.1	7,900	FEB 1989
OPERATING SYSTEM	75	1.3	24,000	MAY 1991
DATA BASE MGMT.	75	1.2	7,300	JUN 1989
DMS NETWORK CONTROL	40	1.2	5,000	JUN 1989
DMS OPERATOR INTER.	150	1.0	15,900	AUG 1989
TOTALS:	840		124,800	

B.3 SCHEDULE INFORMATION

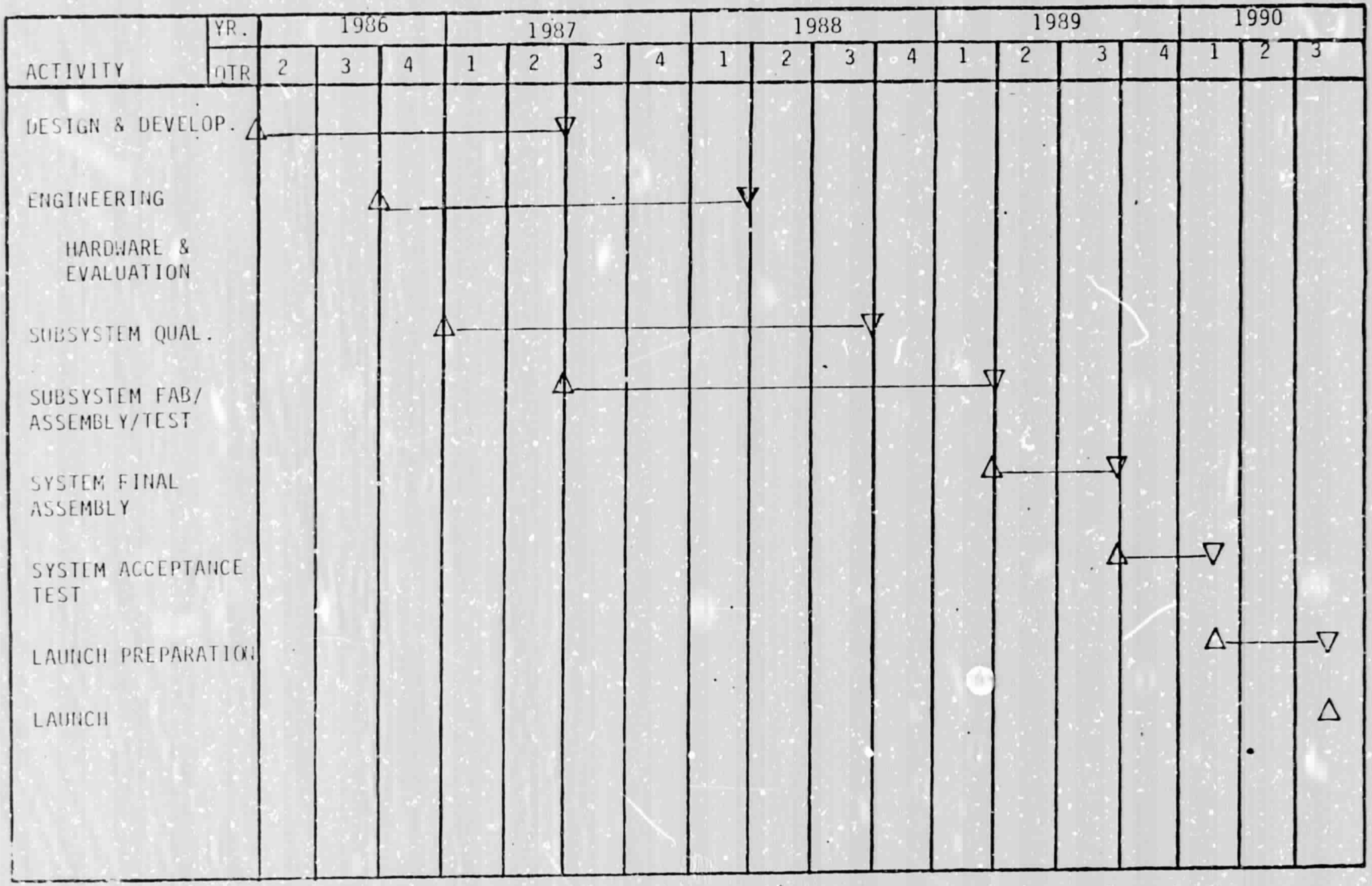
A preliminary evaluation of the schedule requirements for the hardware and software elements was performed.

For the hardware schedule, General Electric's related experience on such programs as DSCS, Landsat D, and MACS was utilized. Factors that contribute to schedule development include design maturity of the subsystem and components, shuttle launch compatibility, and "man-rating" requirements. Based upon the limited definition of the DMS and ICS, it appears that these elements would be able to meet a 52 month schedule from program start to launch. This is based upon the preliminary schedule for the DMS and ICS shown in Fig. 7.

The software schedule estimates were developed by the PRICE model and the data were presented in Fig. 6. It is observed that the largest schedule element is the Operating System software, requiring a 60 month time-span. However, by breaking down the software development activities into parallel paths, it is probable that a 52 month schedule can be met.

Fig. 7

PRELIMINARY SPACE STATION SCHEDULE FOR DMS & IC'S



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